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THE GIFT OF
Dr. Carey P. McCord

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Carey P. McCord

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LEAD DISEASES:

A

TREATISE

FROM THE FRENCH OF

L. TANQUEREL DES PLANCHES,

WITH

NOTES AND ADDITIONS

ON THE USE OF

LEAD PIPE AND ITS SUBSTITUTES.

By SAMUEL L. DANA, M. D., LL. D.

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DEDICATED
TO
JAMES JACKSON, M. D.
PROFESSOR EMERITUS OF THE THEORY AND PRACTICE OF MEDICINE
IN
HARVARD UNIVERSITY,
IN GRATEFUL REMEMBRANCE OF THAT KINDNESS WHICH HE HAS EVER SHOWN
AS
TEACHER, PHYSICIAN, FRIEND,
TO THE
TRANSLATOR.

ADVERTISEMENT.

On presenting the following book to the English reader, it may be proper to state, that it is both a translation and an abridgment. The original French treatise is in two volumes, octavo, comprising about eleven hundred pages. In condensing the work, I have aimed to give faithfully the meaning of the author, without confining myself to a simple translation of his language. In selecting portions of the original to form the body of this work, I have been guided more by the practical, than the theoretical results and views of the author. The historical details have been also very much compressed, and it is presumed that all which was essential has been retained. I have divided the work into Parts and Chapters, a feature not in the original. I trust the unity of the work is preserved, without violence to the original plan and intention of Tanquerel. I have observed that the designating name of the author is variously used. Sometimes he is called 'Tanquerel, sometimes Des Planches, sometimes, by French, English and American writers, Tanquerel Des Planches. I have preferred a designation sanctioned in a Report to the Royal Academy of Medicine. In the following pages, the Preface excepted, wherever the author speaks in the first person, I have uniformly used the name "Tanquerel."

The treatise of that author presents the best account of lead diseases to be found in medical literature. There is a later work, "On Lead, and its Action on the Human Body." This is in the German language ("*Das blei und sein wirkungen auf den thierischen korper, &c.* Dr. Ferdinand Rumpelt. 8° pp. 268. Leipzig, 1845.") From a notice in the American Journal of the Medical Sciences, Vol. xii. 1846, it may be inferred, that while this work confirms the observations of Tanquerel, in many particulars, it can by no means supersede his

volumes, which will long be considered classic. Still, it is to be hoped, that the work of Rumpelt may become accessible to those, who, like myself, are unable to read the original. In the treatise of Tanquerel, it may not be doubted that a vast fund of information on lead affections is presented, not only to the physician, but to all who are concerned in the various trades where lead is used. If we consider how common are lead disorders, since the extensive use of lead pipe has been introduced, it may well be said, that a treatise on those affections is of universal interest. I have endeavored to set forth the substance of Tanquerel's volumes, in a form, which, while sufficiently technical for the medical, is not repulsive to the general reader; a form which, it is hoped, will be found both professional and popular.

Tanquerel began his inquiries on lead diseases in 1831. In 1834 he published a thesis on lead paralysis, and in 1838, the work, whose results are here offered. The original work was ably, extensively, and very favorably noticed in the "New York Journal of Medicine, &c." for September and November, 1844. Except from this source, the American physicians, with few exceptions, have had no opportunity to learn the contents of Tanquerel's volumes.

This work was crowned with the Montyon prize of 6000 francs, by the Royal Academy of Medicine, in 1841. The committee consisted of Roux, Magendie, Serres, Larrey, De Blainville, Savart, Breschet, Dumeril, and Double. They reported, that the treatise of Tanquerel completely fulfilled the intent of the founder of the prize, being the best work improving medicine or surgery, and diminishing the danger of certain trades in the mechanic arts. Had not the committee on medicine and surgery awarded the prize to Tanquerel, the committee on the unhealthy arts were about to award him from the Montyon fund a remuneration. I have ventured to introduce a few Notes, all of which are marked S. L. D., and an Appendix. In this last, several interesting subjects are discussed, particularly the use of lead as a water conduit, and the action of well water, and that of rain, pond, lake and river, upon lead. A part of these remarks has been already partially before the public; but it is presumed that they are yet not wholly uninteresting, nor unworthy serious consideration.

I would here gratefully acknowledge my obligations to Dr. J. C. Dalton of Lowell, Dr. Horatio Adams of Waltham, and Dr. Webber of Charlestown, N. H., for their valuable letters, communicating facts in relation to lead pipe, and the diseases caused by water passing through it. I am happy to express my thanks to Dr. John O. Green, of Lowell, for the privilege of ready access to his extensive and choice

medical library, rich in works relating to public hygiene ; and to Dr. A. A. Hayes, of Lowell, and Dr. James R. Chilton, of New York, for the account of their chemical examination of various waters, and the effect of those waters on lead pipe.

I am under especial obligation to the Rev. Dr. Lamson, of Dedham, for the use of his copy of Tanquerel's Treatise, and for having first brought that work to the notice of the medical profession in this country. I trust that this humble attempt to extend the knowledge of Tanquerel's observations, will show the Rev. Doctor, that his efforts in this cause have not been fruitless.

S. L. D.

LOWELL, June 17, 1848.

PREFACE OF THE AUTHOR.

Numerous works, many of which may be traced to a very remote antiquity, have been published upon Lead Colic. This form of lead disease earliest attracted the attention of observers, and soon absorbed it entirely. But lead does not cause colic only. Its deleterious influence upon the animal economy is shown by various disorders. It is remarkable that, during an age distinguished for exact and severe observation, the history of lead diseases was unwritten. Many of the characteristics of these diseases were noted, especially by modern authors. But other lead diseases were always considered subordinate to colic, and no where do we find a description of them isolated and complete. In short, the pathogenic conditions, which influence their development, were not understood. I have used every effort to fill this remarkable void in science, and it is only after eight years of study, that I have decided to give my researches to the public.

Lead diseases may be classed under four well determined forms, — Colic, Arthralgy, Paralysis, and Encephalopathy. These affections have an independent existence, and have no real and necessary relation, except their common origin.

Notwithstanding the works published on lead colic, many points in the history of this disease demanded new researches. The facts that I have collected have enabled me to point out many established errors, and to add to our knowledge of this disease. The description found in this work is believed to be more complete than that of preceding authors. However this may be, their writings have been of great assistance in directing my researches upon this, the most common form of lead disease. But of the characteristics which mark the other forms of this poison, I found in these writers only isolated and often incomplete observations. To collect the materials for my descriptions, I have often been left to my own researches. I have attempted, from

extensive observation, to give to the description of these diseases as much exactness as possible, and thus to authorize the distinction that I have endeavored to establish, between all those forms of lead affection which have been so long confounded.

The plan that I had to pursue was in no part pointed out, and called for long and difficult clinical studies. The Hospital of Charity, where nearly all the lead diseased workmen in Paris or the environs (the number of whom is considerable) resort, has furnished me the means of carrying on my observations upon an extensive scale. The physicians of this vast establishment have granted me every facility desirable for devoting myself to these inquiries.

For eight years I have visited the patients of the Hospital of Charity, afflicted with lead diseases. During this time there were few who applied for advice, or who entered the wards of this hospital, who escaped my examination.

Although these diseases may be rarely observed in a city, the individuals attacked being generally poor, I have yet been able sometimes to compare my hospital observations with those of city practice. My descriptions are a faithful recapitulation of the facts afforded by clinical observation.

At the hospital I could only study the morbid phenomena which lead diseases manifest during life, and the traces that they leave after death, but the different influences which are present at the development of these affections are to be studied only in the midst of the labors which cause them.

To observe the etiology, I have also made numerous experiments upon animals.

Finally, I did not neglect the researches of chemical analysis to discover lead in the system. Here I have availed myself of the well known kindness and skill of M. M. Chevalier, Devergie, and Guibourt.

Such is the substance of a work that I give to the public, with confidence in the hope that it may be useful to humanity, and contribute something to the progress of science.

LEAD DISEASES.

INTRODUCTION.

GENERAL CONSIDERATIONS ON LEAD DISEASES.

THE term Lead includes all its preparations. When it is reduced to a state of extreme division, and introduced into the animal economy, that experiences more or less serious disease. This disease manifests itself by several well determined symptoms.

It is remarkable, that the two nervous systems which govern external and internal, or organic and animal life, are both equally liable to become the seat of lead diseases. The form of these disorders is not less remarkable; in the system of internal life, nervous action only is increased; on the contrary, in that of external life, the phenomena of sensation and motion are sometimes increased, and sometimes lost. When lead exerts its influence upon the abdominal viscera, colic appears in all its varieties. If the spinal nervous centre is affected, then appear in the organs of external life those sharp pains which characterize arthralgy, or that loss of the power of motion or of sensation, which denotes lead paralysis, or anæsthesy. If the head, or *encephalon* is affected, delirium, convulsions, or coma distinguish lead encephalopathy. The physiognomy of lead diseases is peculiarly marked.

Diseases caused by this metal are not of equally frequent

occurrence. The following table, comprising all the observations collected for this work, shows this relation :

Colic,	1,217 cases.
Arthralgy,	755 "
Paralysis,	127 "
Encephalopathy,	72 "

Colic is the most frequent form of lead disease. It seldom appears alone, being often complicated with arthralgy, sometimes with paralysis, and even with encephalopathy. Sometimes each of these diseases appears alone, sometimes two or three are combined in the same individual. Colic, arthralgy, different kinds of paralysis, and encephalopathy are equally liable to appear at the commencement or close of disease.

Although the different forms of lead disease have no direct and reciprocal influence upon their development, yet one form of this disease predisposes to another, for the presence of lead in the system shows that it has become susceptible to all the train of lead disorders, and it is not surprising that individuals are often attacked with colic, while suffering from other lead diseases.

The development of other forms of lead disease is not dependent on the violent or light attacks of that already acting. Arthralgy, paralysis, or encephalopathy will not more frequently be developed after a case of severe, than of mild colic.

Lead diseases of a similar, or very different form, appear in the same individual at different periods. The earlier kind of lead affection does not determine the form of that which manifests itself later.

Suppose a person attacked the first time with lead colic, the second time it may be with colic again, arthralgy, paralysis or encephalopathy; yet, circumstances around him have not changed, and no apparent alteration has taken place in his organism; why then is not the manifestation of lead in the system the same?

It is very remarkable, that in one hundred individuals exposed to the action of lead, in apparently the same circumstances, some are taken with colic, others with arthralgy, these with paralysis, those with lead encephalopathy. Why is there a greater disposition to be attacked by one form of lead disease, than by another? Is it from a particular state of the organism, from the

mode of absorption of the lead, from its quantity, or its quality ? It is a question that must be discussed with care.

What has been said, sufficiently proves that lead colic, arthralgy, paralysis, and encephalopathy are distinct diseases, independent of one another, which may each alone show its peculiar features, and that they are not sympathetic nor consecutive effects of colic, the most frequent form of lead malady. Because the laborers in mercury are often attacked with trembling of the limbs, salivation, colic, &c., is it to be concluded, that one of these diseases is the consequence of the other ? Certainly not. They are diseases like those produced by lead, having a common origin.

The varieties of lead disease occupy different organs ; the functional lesions which reveal them, must then offer to the observer very different morbid appearances. Consequently, these diseases display themselves, by a lesion, sometimes of the sensibility, sometimes of the motion of the affected parts ; the result of this is, that varied morbid effects are often observed in the same organs. Of the four fundamental lead diseases, three are rapid in their progress, whilst paralysis is generally of a chronic nature. Finally, the treatment proper for one of these diseases is not suited to another.

Since, therefore, the diseases resulting from the direct action of lead upon the different organs of the system, present such great differences in their physiognomy, progress, duration, and treatment, their history must be described separately.

In the arrangement of this work, the phenomena exhibited in the system, due to the effects of lead, before the manifestation of its specific diseases, are first described. These phenomena are termed "*primary effects*." They are the precursors of all the forms of lead disorder. Lead colic is then described, being the most frequent and best known. Next is the description of lead arthralgy, paralysis comes immediately after ; and, lastly, encephalopathy, being the most rare form of lead disease.

A uniform order is adopted in description. The definition, history, causes, symptoms, complications, diagnosis, progress, duration, termination, prognosis, anatomical changes, seat, nature, and treatment of each of the lead diseases are in turn noted. While each form of disease is described as if it existed alone, care has been taken to mark the relations these diseases bear to each other. The several monographs thus form a connected whole.

The names, heretofore given to lead diseases, have been retained, as lead colic and paralysis. But names have been coined for others, which indicate as perfectly as possible the nature of the affection, as arthralgy, anæsthesy, and encephalopathy, the term *lead* being prefixed to each.

The work closes by pointing out the means to be used, for preventing these painful diseases.

ACTION OF PREPARATIONS OF LEAD
ON THE SYSTEM,
BEFORE THE DEVELOPMENT OF LEAD DISEASES
OR
PRIMARY EFFECTS OF LEAD.

LEAD introduced into the system, before the development of its diseases, may manifest its presence by a specific action upon the greater part of the solids and liquids of the organism. This previous action is termed "*primary effect*" of lead. The causes of this are the same as those of lead diseases. All individuals who inhale or swallow particles of lead are liable to experience this effect.

According as the person is in air more or less filled with particles of lead, or as he swallows directly a greater or less quantity, the characteristic phenomena of the primary action of lead can be established more or less promptly and completely.

Thus, all the characteristic traits of the primary effects of lead, may be very quickly observed in many of the workmen engaged in preparing lead for the arts, and who are habitually in an atmosphere of lead dust and vapor; as workers in white lead, minium, litharge, lead mines, &c. These individuals really absorb, as will soon be proved, almost constantly emanations of lead by the respiratory and digestive organs. It is not then surprising that their systems are soon saturated with lead, and that it manifests its presence there by various signs, before it causes disease. On the contrary, among those who labor in an atmosphere slightly charged with the dust or fumes of lead, and who are only occasionally exposed to its influence, only one or two characteristics of the primary effects of lead are found; as in painters of buildings, type-founders, manufactures of earthen

pottery, &c. All the effects of the primitive action of lead, are developed in these last individuals only after a very long time.

None of the primary effects of lead are found among workmen who handle it in a fixed state, and who, consequently, are never in contact with an atmosphere where lead particles are disseminated; as sheet-lead workers, &c.

Sometimes lead preparations, introduced into the digestive organs under the form of medicines, or mixed with the drink or food, at the end of some days or months may develop the characteristic phenomena of the primary effects. But it is rarely that all these distinct phenomena appear in the same person.

Hence all individuals susceptible of contracting colic or other lead diseases, may experience, in the same etiological circumstances, the effects of the primitive action of lead upon the system, before the development of these diseases. Even where the circumstances of contact with lead are the same, some individuals are more susceptible than others.

But, as the circumstances which assist or oppose this action, are the same as those which concur in the development or prevention of lead diseases, the discussion of this important etiological point will be referred to in the article *Causes of Lead Colic*, &c.

The characteristic phenomena of the primary effects of lead are the following.

1. *Leaden Discolorations of the Teeth and Mucous Membrane of the Mouth.*

The first and most frequent symptom of the presence of lead in the system, is a very peculiar discoloration of the gums and teeth. The portion of the gums nearest the teeth, to an extent of one or two lines, generally assumes a bluish or slate gray color. The rest of the gums often present a very light bluish red color, which insensibly disappears in the rosy tint of the mucous membrane, which covers the other portions of the mouth.

Sometimes the slate color tints the whole extent of the gums, and even spreads to the entire mucous membrane of the mouth.

The mucous membrane of the mouth and tongue of a worker in white lead, was entirely of a slate blue color; here and there some rosy points could barely be perceived. Sometimes, blue *traces*, or spots, are perceived on the mucous membrane of the mouth.

In a great number of cases, the portion of the gums nearest the teeth alone becomes of a slate blue color, contrasting with the rest of the gums, which preserves its original rose tint. The gums, before acquiring a complete slate color, first pass through a reddish violet tint, which finally becomes blue after a longer or shorter time.

The mucous membrane of the mouth then appears susceptible of several degrees of this discoloration, and of being unequally tinged with blue through its whole extent.

This discoloration of the gums cannot be removed without much difficulty. It is only by friction repeated several times a day for a long time, and the use of water acidulated with sulphuric, or hydrochloric acid, that it can be completely cured.

The portion of the gums which becomes blue, very often experiences a remarkable change; sometimes it is so much reduced as to be no thicker than a sheet of the thinnest paper, or else, which is more common, it is contracted. In this last case, the interdental processes insensibly disappear, and the concave, or arched edge of the gums is increased, in consequence of molecular absorption, which occurs in their tissues without a solution of apparent continuity.

When this absorption is completed, the teeth are found to be destitute of a portion of the gums, they are denuded. Then the gums very often present a border more or less projecting, which sometimes looks as if cut in peaks. This change in the nutrition of the gums always succeeds the bluish discoloration. But the latter often disappears as absorption removes the blue part of the gums; so that the resulting border which remains shows scarcely a shade of blue.

Generally, the blue color and loss of substance of the gums, are not found equally decided on both sides of the alveoli. The anterior part of the jaws is where this double alteration is usually most marked. The gums of the lower, are generally a little more changed than those of the upper jaw. It sometimes happens that only the gum covering two or three teeth becomes blue and is absorbed. It has been observed in a few cases, that congestion had taken place in the gums colored blue, and that the least touch made them bleed.

A solitary case only, in a white lead worker, of ulceration of the upper alveolar border of the gums in both jaws has been noticed. In this man, the mucous membrane of the mouth was

almost entirely of a blue color, but he did not suffer. The ulceration disappeared under the use of lotions of acidulated water, successfully prescribed to remove this blue color.

Generally, in persons whose gums, from contact with lead, have acquired a slate blue tint, the teeth at their base or neck are of a very dark brownish color, while the crown often appears of a clearer brown, bordering upon yellow or green. This coloring may be confounded with, or mistaken for, the ordinary tartar which covers the teeth. The incisors, and the canine teeth especially, are colored brown, but the whole may be tinted, though it is seldom that they are so in an equal degree. When the gums have undergone absorption, the brownish color of the neck of the teeth is only more decided.

Teeth thus discolored are finally ruined, they become very brittle, break, decay, and are lost long before the usual time.

This coloring matter adheres very closely to the bony substance of the teeth, and seems almost to be combined with it; like that of the gums, it is with very great difficulty that it can be removed. It finally disappears by the use of the same means. In general, when the blue tint of the gums is very marked, the brownish color of the teeth is very decided, and *vice versa*.

This coloring matter of the gums and teeth is sulphuret of lead. Oxygenated water, in contact with gums and teeth thus colored, gives rise to whitish traces of sulphate of lead. The gums and teeth of a grinder of colors, who died of lead encephalopathy, were digested in hydro-sulphuric acid. In twenty four hours, a great part of the gums which were not apparently covered by this bluish discoloration, became deep blue. These chemical experiments prove the existence of sulphuret of lead.

How is the formation of this sulphuret of lead to be explained? Food, when masticated, leaves particles between the teeth. These remains of alimentary matter always contain a little sulphur, and are speedily changed, forming sulphuretted hydrogen gas. This gas and the lead particles, which pass into the mouths of individuals who inhale or swallow lead, come in contact; then by chemical affinity these substances are decomposed, sulphuret of lead formed, and deposited on the gums and teeth precisely where the sulphuretted hydrogen is evolved.

If free sulphuretted hydrogen should be formed in other parts of the system than the mouth, without doubt, in case of lead disease, the presence of sulphuret of lead would be detected wherever the metal and gas came in contact.

Sulphur enters as an element into many of the solids and liquids of all organism; but it is intimately united with other substances constituting animal matter, which act as obstacles to its disaggregation, and consequently to its transformation, into free sulphuretted hydrogen, susceptible of combining with lead.

Saliva, for example, in whose composition there is a considerable quantity of sulphur, is not decomposed by lead; in persons who have been examined in this respect, its sulphur does not combine with the numerous particles of this metal that it holds in solution, or simply in a state of mixture. No anomaly of composition was observed in this saliva, when examined with a microscope, and also by chemical analysis.

The loss of the substance of the gums, by interstitial absorption, or atrophy of their particles, their congestion, and even their ulceration, the decay and destruction of the teeth, may perhaps be explained by the obstruction of the capillary vessels of those parts, which accumulate sulphuret of lead. When nutrition is no longer possible, the tissues are changed.

The brownish color of the teeth, and the slate blue color of the mucous membrane of the mouth, are developed in five or six days, or months, and sometimes not until after whole years of exposure to contact with particles of lead. Thus a great number of workers in white lead, &c. show marks of their occupation in a few days. House painters are not usually affected till after some months' practice of the trade, whilst polishers of crystals exhibit this mark of the primary effects of lead, only after many years of labor, &c. &c.

The color of the gums and teeth which has just been described, is observed in individuals only, the mucous membrane of whose mouth is in contact with particles of lead. In an examination of the mouths of seven hundred and eighty-five individuals who had not worked in preparations of lead, or swallowed it in any way, not the least trace of the specific discoloration produced by lead was discovered.

This discoloration, then, affords an excellent means for discovering whether an individual has inhaled or swallowed particles of lead. The conclusion that the physician may draw for the diagnostic of certain lead diseases, from this sign of the primary effects, will be hereafter mentioned. A few only who breathe or swallow particles of lead for some time, have their

teeth and gums covered with sulphuret of lead. It is not a common occurrence.*

2. *Lead Taste, Breath, and Odor.*

Those upon whose teeth and gums there is a considerable deposit of sulphuret of lead, often complain of a very peculiar taste. This is generally a sugary, styptic, and astringent taste, like that produced by a preparation of lead deposited upon the mucous membrane of the mouth. Others compare this taste to something at once fetid and styptic. Saliva is not generally increased, some say the mouth is dry; it would seem from this that the secretion is sometimes less than in the normal state.

The breath often has a characteristic odor. The sensation of fetor that it causes in the observer can give an idea only of it; it is impossible to express it. It may be called *lead breath*. A person who has once experienced its effects, can never confound it with any other. Some persons are conscious of this fetor of their breath; they say that they "*poison themselves*."

In workshops, where particles of lead are disseminated in the atmosphere, a very peculiar odor is perceptible; it is that of lead, the emanations from which affect the sense of smell. If a piece of metallic lead is rubbed for some minutes with the fingers, the olfactory organs are affected with a peculiar sensation from contact with lead emanations detached by this process.

This change of taste, breath, and smell, evidently arises from the contact of particles of lead with the mucous membrane of the mouth, bronchiæ, and nose, and with the fluids exhaled upon their surfaces. What confirms this opinion is, that particles of lead are sometimes discovered, either with the saliva, or nasal mucus of workmen.

3. *Lead Jaundice.*

(Leaden yellow color of Authors.)

One of the most important general changes produced by the primary effects of lead upon the system, is a peculiar discoloration of the solids and liquids. This is lead jaundice.

* Dr. Chowne, (Lancet, October 26, 1844,) states that the presence or absence of this blue line is not connected with the administration or non-administration of lead. Pathologists generally adopt the opinion of Tanquerel. S. L. D.

When it exists in the greatest degree, the skin is of a foul, earthy yellow tint; if the disease is less severe, it appears of a pale, slightly ash yellow. This color appears more decidedly in the face than elsewhere, though the skin of the body and limbs is also discolored, but in a less degree. This pale yellow, generally united with a very marked bluish discoloration, may be observed very decidedly in the white of the eye.

It may be thought that this color is only owing to the scurf which often covers the bodies, &c. of workmen; or to particles of lead lodged in the folds or crevices of the epidermis. It is not; for persons thus affected have often been placed in sulphurous baths, and afterwards washed in plain baths with brown soap. The jaundice has never disappeared, even after these repeated washings.

The urine is of a dull yellow color. Nitric acid does not show that play of colors indicated by Berzelius as a proof of the presence of the coloring principle of bile. The shirt of the patient is not stained yellow by contact with this liquid. The excrements were a very decided fawn yellow color. The serum of the blood presented a slight yellow reflection, but this yellowish color had no tinge of green.

After death, this earthy yellow tint has been found in nearly all the organs of the system, the brain, lungs, heart, intestines, stomach, liver, kidneys, and bladder.

Lead jaundice is sometimes rapidly developed in consequence of exposure to emanations of lead. Workers in white lead, &c. who live and breathe in an atmosphere filled with particles of lead, often become yellow after working ten or twenty-five days.

Workmen who merely handle lead preparations do not generally absorb a quantity large enough to cause jaundice, it is only after months, or even years, that it is entirely developed, as in painters of buildings, manufacturers of German cards, &c. &c.; a very large number are not affected at all, as, for instance, workers in chromate of lead, varnishers of metals, &c.

For the same reason this peculiar yellow tint is very rarely developed in persons, who, though not working in lead, are yet in contact with its particles.

Lead jaundice is then the result of absorption and of the accumulation of a great quantity of particles of lead in the system. But how does lead absorbed into the system act, so as to produce this general yellow tint? The answer is difficult.

Physiological and pathological observation of those affected with cancerous diathesis, or long standing intermittent fever, and the discoloration produced by syphilis, and the internal use of nitrate of silver, lead to the conclusion that lead jaundice, or the tinting of the solids and liquids of the system with this earthy yellow hue, is the result of a change in the blood effected by lead.

It will hereafter be shown, that by the aid of chemical analysis, lead has been discovered in the blood of persons affected with lead jaundice.

This pale and earthy color occurs only in persons whose respiratory and digestive organs have absorbed particles of lead. If the places or circumstances in which lead was absorbed are abandoned, by degrees this characteristic tint disappears and never returns.

It is impossible to confound *lead* jaundice with *common* jaundice, which is caused by a difficulty in the nervous system. Their yellow color resembles each other no more than lead colic resembles common stomach-ache or pain in the bowels, no more than the copper color of syphilis resembles the red color of erysipelas or of simple and legitimate erythema, no more than the yellow color of cancerous cachexy, or that of intermittent fever or common jaundice resemble each other. The earthy yellow of lead jaundice does not border on green like common jaundice, for it is not the extravasation of the bile from its common reservoirs, and its diffusion in the system which causes lead jaundice. Lead jaundice differs from common jaundice in no slight degree. No physician, who has seen the dirty or earthy yellow produced by lead, will confound it with common jaundice, the color of which, however slight it may be, always inclines to green. The color of lead jaundice is less bright, consequently it shows less in the skin and other tissues than that of common jaundice. Finally, one jaundice is the result of a specific alteration of the blood; the other owes its coloring principle to the bile, which tints the solids and liquids of the system by passing into the blood. The great difference in the causes must necessarily produce different effects.

Common jaundice, produced by a mechanical obstacle in the course of the bile, or by disease of the liver, can still less be compared to *lead* jaundice. In the first of these diseases, pathognomic phenomena appear in the biliary apparatus; nothing of the kind takes place in the second disease, the secretive and excretive organs of the bile are in a good state.

The yellow tint which follows intermittent fever is slightly *livid*. That which appears in cancerous cachexy is a peculiar *straw yellow*, consequently these two yellow tints cannot be confounded with lead jaundice.

In some authors, lead jaundice is designated by the improper expression, *leadén tint*, for this color has not the *bluish gray* appearance of metallic lead. The first observers who used this expression, probably meant to say, that this peculiar tint was produced by lead; therefore they called it *leadén tint*. This interpretation justifies in some degree the expression.

4. *Lead Emaciation.*

At the same time that lead jaundice appears, or some time after, a diminution of general nutrition has occasionally been observed.

This character of the primary effects, essentially and peculiarly requires for its promotion a greater quantity of lead to be accumulated in the system, than do the other phenomena that have just been pointed out. Emaciation is generally noticed only in those who work lead in large quantities, and who are almost constantly in an atmosphere loaded with lead emanations, as in white lead workers, manufacturers of minium, litharge, &c. Emaciation is found only in those who have absorbed the largest quantity of lead.

Emaciation is general, but is often more marked in the face, which looks wrinkled, and the individuals so affected have all the appearance of premature old age. These wrinkles give an expression of sadness to some faces.

This loss of flesh is an interesting subject of study. Workmen who were fleshy on entering lead establishments, sometimes become so thin as to be only skin and bone, though emaciation does not often make so much progress; before this time, the individual is attacked with a lead disease, which obliges him to leave his business, and consequently to withdraw from contact with lead. Emaciation occurs sometimes in fifteen days, or a month, and sometimes not till after years of contact with lead emanations.

The cause of this wasting of flesh is owing to the change of blood produced by lead. Severe labor, and unhealthy diet, to which many workers in lead are subject, is not the direct cause

of this loss of flesh. Individuals who had been accustomed to more severe, and less lucrative employments, who grew fat under their work, entering the lead factories, and being exposed to lead emanations, have shown great emaciation, and its consequent loss of strength and that physical energy, so marked before working in lead.

5. *State of the Circulation.*

Stoll mentions having observed, tension, fulness, hardness of the pulse of lead workers. Tanquerel has never observed this state, but on the contrary, sometimes found the pulse small, slender, slow, easily depressed, in workmen exposed to breathe and swallow a great quantity of lead, as workers in white lead, minium, &c.

In some rare cases, there is found with the preceding alterations of the arterial circulation, a marked diminution of the pulsations, the beats being 40, 45, 50, 55, per minute, the normal state in the subject, before handling lead, having been from 60 to 70 pulsations. This diminution of the pulse is also observed in individuals who take medicines composed of lead preparations.

An irregularity of arterial pulsations, or symptoms characterizing disease of the large arteries and heart, have not been observed among the primary effects of lead, which may be now briefly recapitulated.

The discoloration of the gums and teeth is the most common symptom of the primary effects of lead, and that which is most quickly developed. There are a great number of workers in lead, in whom this is often the only characteristic appearance of the primary effects. These cases occur where only a small quantity of lead particles is disseminated in the air, and consequently absorbed in minute quantity, as among tinman, laborers in type foundries, potters, &c. To these may be added, individuals among manufacturers of chromate of lead, varnishers of metals, and some persons who use lead preparations internally as medicines. Lead discoloration of the teeth and gums is very rare among these last classes.

The sugary taste, fetid breath, yellow color, emaciation, and different changes in the circulation, are only developed in individuals, in whom a great quantity of lead particles have accumulated in a very short time, as among manufacturers of white

lead, minium, &c. The frequency of these characteristic phenomena of the primary effects, corresponds to the order in which they are above enumerated.

In individuals who present one or many signs of the primary effects of lead, all the other functions of the system are perfectly well executed, or at least they are not impeded by its action. The subject continues his work free from pain. These primary effects may precede the development of lead diseases by some hours, or even by whole years. It is not uncommon to see persons, who all their lives bear traces of the presence of lead in the system, without ever being attacked by lead diseases.

When the discoloration of the gums and teeth betrays the presence of lead, the possible access of lead disease, especially if the individual continues exposed to the same circumstances, may be reasonably inferred. When all the characteristic features of the primary effects of lead exist in an individual, it is almost certain, that, continuing exposed to the causes, he will soon be attacked with lead disease. Even the leaden discoloration of the gums and teeth, combined with the earthy yellow tint of the skin, authorize the conclusion that the development of a lead disease is near.

But, when all the primary effects have been developed, yet removal from their cause may prevent attacks of other lead diseases, and the primary effects may cease. Jaundice and emaciation disappear first, after months or whole years; the discoloration of the gums and teeth will remain for a very much longer time, especially if appropriate means for its removal are neglected. It is very seldom that diseases caused by lead are not preceded by the development of the characteristic phenomena of its primary effects.

PART FIRST.

LEAD COLIC.

CHAPTER I.

DEFINITION AND SYNONYMES.

WHEN pathological anatomy reveals negatively only, the seat and nature of a disease, its exact definition is the enumeration of its characteristic features during life.

Lead colic is neuralgia of the digestive and urinary organs, produced by the introduction and absorption of lead in a molecular state into the system. This neuralgia is characterized by sharp, continuous, abdominal pains, attended by exacerbations, diminishing, or *if* increasing but little, by pressure, accompanied with hardness, and depression of the walls of the abdomen, obstinate constipation, vomiting or nausea, excretion of intestinal gas through the mouth, anorexy, dysury, slowness and hardness of the pulse, agitation, anxiety, an increase of the sensibility, and perversion of the contractility, and secretions of the diseased organs.

This definition, although rather long, does not enumerate all the phenomena observed in some cases of lead colic, as the symptomatic expression of that disease. This definition includes the phenomena which generally betray the existence of this disease. Not every symptom pointed out in the definition, but the greater part, generally exist in all cases of lead colic.

Every definition of a disease, founded on a succinct enumeration of its principal symptoms, is open to the objections which have been attempted to be obviated in that now given of lead

colic. For what disease of the nosological system always appears with the train of all its symptoms? The definition makes known the cause, seat, nature and pathognomical characters of lead colic. What more can be asked? The greater part of preceding authors have not given, properly speaking, a definition of lead colic.

M. Merat, in his treatise on *Metallic Colic*, gives that name to the disease caused most often by lead, copper or their preparations, and which inclines to terminate in paralysis, caused by continuing in the same circumstances, or by defect in the treatment, or the use of an inappropriate medicine. This is no definition; as M. Merat does not define the *colic most often caused by lead*. To say that lead colic is a colic inclining to terminate in paralysis, in such or such circumstances, does not define the first of these, since lead colic and paralysis are two distinct diseases, produced directly by lead. It is like defining mental alienation as a disease of the brain, inclining to terminate in epilepsy.

Tronchin has defined painters' colic, as colic terminating in epilepsy, or paralysis. The greater number of other authors have defined lead colic, "as colic produced by lead preparations." Evidently no definition.

M. Grisolle, alone, has endeavored to give a definition of lead colic. "This disease," he says, "is characterized by paroxysms of sharp abdominal pains, not increased by pressure, accompanied by bilious vomitings, and obstinate constipation, slowness of pulse, in short, cramps and other painful sensations in the thoracic appendages and pelvis," (*Thesis sur la Colique de plomb*.) This definition is not very complete, and comprehends two distinct diseases, lead colic, and arthralgy.

Preceding authors, thinking that neuralgic pains in the limbs, epilepsy, lead paralysis, &c., were the effects of lead colic, have ever considered these as mere accidental circumstances, in their definitions of lead colic. But now it has already been shown, and will be shown again and again, that all these accidents produced by lead, form distinct diseases, having a common origin, the same terms for their definition are wholly inapplicable.

If the object was to define diseases produced by lead, then lead colic, paralysis, arthralgy and encephalopathy should be included in the definition. But, at present, attention is devoted to one form of lead disease, viz., colic.

SYNONYMES.

Ancient writers, who have described lead colic only when it arose from the ingestion of lead preparations into the stomach, have given it no particular name. But they have described colics greatly resembling that produced by lead, and which they named according to the idea they had formed of their nature, and not according to the specific cause, of which they were ignorant.

Thus the *pestilential colic* of Paul of Ægina, the *serous colic* of Lepois, the *bilious colic* of Milon, Citois, Sennert, Rivière, Craanen, Muys, the *scorbutic colic* of Schenke, Engalenus, Junken, take their names from their presumed cause.

Physicians of a later period, observing lead colic in countries where they practised, and not finding in books a detailed description of this disease, gave this colic the name of the country where they had observed it; hence the names, Poitou, Devonshire, Normandy and Madrid colics. Citois, a physician of Poitou, is the first who published a dissertation on this disease; he proposes to call it Poitou colic, a name adopted by most writers of the seventeenth and eighteenth centuries.

Nevertheless, some authors wished to establish varieties in Poitou colic, as *vegetable colic*, and *mineral colic*, according as it was produced by cider, light wines, &c., or by lead preparations. The first of these varieties, *vegetable colic*, was generally nothing but the symptomatic expression of lead colic; and these writers, ignorant of the true cause, attributed it to the use of wine or cider of bad quality, not discovering its adulteration with lead preparations. Sometimes, wine and cider thus adulterated, when drank in large quantities, caused not only lead colic, but divers other diseases, such as dysentery, &c. Truly the union of these two diseases must present a very different physiognomy from that of simple and proper colic. Is it then surprising, that without a chemical analysis of those drinks, they sought, by the expression *vegetable colic*, to define, aside from lead colic, a morbid state formed by the union of this last and a disease of a different origin? The disease, whose history has thus been traced, has often been called *painters'*, *potters'*, *founders'*, and *plumbers' colic*, &c., according to the professions that most frequently cause it.

The names *colica pictorum* and *colica pictorum* having some

analogy, several writers have given to lead colic the name Poitou colic, *colica pictonum*, instead of painters' colic, *colica pictorum*. And some treatises on *Colica Pictorum*, describe painters' or lead colic only.

The French names Poitiers' colic, and potters' (*potiers*) colic, having some analogy, are often mistaken for each other, by some writers, who consider these two diseases as identical. Those writers, on the contrary, who think that these two expressions mark two different diseases, ought not to consider these two names as synonymous.

Some physicians call this disease *metallic colic*, because they presume that it is caused by other metallic substances beside lead. There is a metallic colic, besides that produced by lead; it is copper, but entirely distinct from lead colic.

Astruc, who placed the seat of this disease in the spinal marrow, wished to give it the name of spine-ache, or rachialgia, an expression adopted by Sauvages. Generally, this disease is named from the cause which gives rise to it, *lead*, or *saturnine colic*, Saturn being the alchemical name of lead.

Some authors wished to call this disease by a name drawn from its characteristic symptoms: *spasmodic* or *convulsive colic*, (Baglivi) colic, accompanied by *paralysis* and *epilepsy* (Camerarius). Henkel affirms, that some writers in his time designate it by the names *intestinal gout*, *internal epilepsy*.

Merat and Palais, relying on the presumed nature of this colic, have called it, the first, *nervous metallic colic*; the second, *metallic enteritis*.

The Spaniards call lead colic *entripado*. The English have given it the name of Bellon, *mill reek*. The Germans designate it by the expression, *huten-katze*, the cat of the founderies, because it tortures like a cat tearing the entrails.

Of all these expressions, the proper ones for designating this disease, are *lead colic* or *saturnine colic*, for they indicate the seat as well as the cause of this disease.

CHAPTER II.

HISTORY.

LEAD colic has existed from time immemorial. Long before the age of Hippocrates, the arts into which lead enters were widely cultivated, and many of the processes have descended to our day. Were men less liable then, than now, to lead colic? Certainly not. The true inference from the silence of early medical writers is, that it escaped their observation, as have other diseases formerly unknown, but now recognised.

The Greek Father (*De morbo Vulgari*, lib. iv. art. 20), describes metallic colic, but it may be inferred from his prescribing minium as a remedy in uterine hemorrhage, that he was probably ignorant of the poisonous effects of lead medicines. Nican-der, the eldest of ancient medical writers after Hippocrates, describes lead colic and paralysis produced by the internal use of the metal; and Celsus, although he does not describe any disorder caused by lead, knew well the danger of its administration (*De re Medica*, lib. v.) Dioscorides goes a step farther. He not only quite accurately enumerates the symptoms of colic and paralysis, arising from lead introduced into the stomach, but seems fully aware that breathing lead emanations caused the same disorders, and speaks of the mechanical means used by the workmen in his day to protect themselves from the effects of an atmosphere lead-charged, (*Sect. de alexipharmcis*, *Dioscorid. Sarac. interpr. Vienn.* 1598.) Galen describes a colic identical with that produced by lead, though unaware of its cause, (*Meth. Med.* t. vi.)

Aretæus (lib. 1, *de causis et sing. morb. Diuturn.*) and Paul of Ægina, (lib. v. ch. 60, *de venen.*) describe lead diseases; the last using almost the very words of Dioscorides. Though he describes an epidemic colic, and another variety, the causes of both of which he was ignorant, yet the description given by Paul of Ægina indicates lead colic only. Similar remarks apply to the exact description of colic recorded by Ætius, (*Tetrabibl.* lib. iv. *serm.* iv.) who, however, seems to have well understood the effects of white lead and litharge taken into the stomach, rank-

ing the last preparation among poisons. Among the Arabian writers, Rhazes, (*oper. parv.* Albulb fil. Zachar. etc. *Tract.* lib. viii.) and Haly-Abbas (*Theor.* lib. iv. cap. 35) well knew the effects of lead preparations on the system, and their remarks apply well to lead colic. Avicenna has given a lengthened description of lead colic, adding to all which was known to preceding writers, his own accurate observations, and defining lead colic and its varieties with a clearness and force, which ought to have made this disease better known in that age, (lib. iv. *Tract.* 1).

Such is the amount of knowledge of lead disease which has existed from remote antiquity. The Greek, Latin, and Arabian writers certainly knew that colic was induced by lead preparations internally taken. They did not know that lead emanations were equally causes of colic. Dioscorides and Avicenna only suspected this. When it is considered how few cases of lead colic fell under the observation of these ancient authors, how rarely they occurred, it is astonishing to find how accurately and graphically they have described the symptoms, termination and treatment of this disease. The evidence that these descriptions apply to lead colic is irresistible; can therefore a different cause be philosophically admitted? Many lead preparations were then in common use, and it is only because the ancients were ignorant of the poisonous effects of an atmosphere loaded with lead particles or emanations, that the cause of a colic, which has been noticed from the earliest times, has been attributed to other sources.

Nor were the ancients wholly free from the effects, though unacquainted with the modern mode of rendering bad wine and fermented drinks sweet by litharge and other lead preparations. They were in those days accustomed to boil the juice of the grape in leaden vessels to obtain a syrup, called *carænum*, *sapa*, *defrutum*, which was added to the wine to preserve it, render it palatable, and prevent fermentation; and the philosophers recommend this process, supposing it harmless (Cato, *de re Rustica*, cap. cvi.; Plin. *Nat. Hist.* lib. xiv. cap. xx.; Columella, *de re Rust.* lib. xii. cap. xx.) The last writer assures us, that it was customary to introduce slips of lead into the vessel of grape juice to retard acetous fermentation. Now what could result from such practices, but acetate or sugar of lead? This it was which became a cause of lead colic so mysterious to the writers of that and even of later times.

In the middle ages, from the twelfth to the sixteenth centuries inclusive, though many writers mention, no special tract appeared on lead colic. No addition was made during this long period to the knowledge already extant. A catalogue of the authors and their date may suffice to fill this gap :

- 1412. Nicolas Nicole, serm. v. tract. viii.
- 1430. Jean-Michel Savonarole. *Practic.* tract. vi.
- 1480. Jean Arculan. *In pract. med.*
- 1496. Alexandre Bénédict.
- 1500. Dulaurent.
- 1532. Andernac.
- 1550. Trincarellius, and Leon Jacchin.
- 1553. Volcher Coëter.

Paracelsus, Droët, Craton, and Engalenus are all to be included in this list. They considered colic and paralysis as mere accidents of lead poisoning, without giving an exact account of their causes. In truth, during the period of these writers, preparations of lead were used as medicines. Paracelsus writes, "*Saturnus purgat febres.*"

Finally, in the seventeenth century appeared many tracts on lead colic, which before had been known only from the obscure sayings of preceding authors, who were inaccessible to the readers of that period. In 1616 was printed at Poitou, the celebrated work of Citois, "*De novo et populari apud Pictones dolore Colico bilioso. Diatriba.*"

The description of symptoms of colic, and of the functional lesions of the cerebro-spinal nervous system, leads to the conclusion that the disease described by Citois differs not in its etiology from lead colic. The epidemic form of this disorder, noticed by this author, was produced by the free and common use of wine, adulterated with lead to remove its acidity, a practice long known, and at that period universally prevalent in Europe, — a practice against which were often directed imperial ordinances as early as 1437. Citois was perfectly ignorant of the cause of the colic which he described; is it not then probable that every case of colic in painters, potters and plumbers, was considered as true Poitou colic? An expression which writers after Citois generally adopted in their accounts of legitimate lead colic, whose symptoms were identical with that of Poitou.

Stockhausen, who practised in the midst of a country of lead

mines, first demonstrated, that Poitou colic, so often described, was produced either by lead particles, or emanations. Hence, after the appearance of his philosophic remarks, lead colic became much more frequent than before. The cause once shown, the attention of physicians was then directed to the malady, and no longer allowed it to go unnoticed. Stockhausen, the physician at the lead mines of Goslar, is the father of the true history of lead colic. He has referred also to various other lead affections, in his treatise which was published at Goslar, 1656, entitled: "*De Lythargyrii Fumo, noxio, morbifico ejusque metallico frequentiori, morbo vulgo dicto Hutten-Katze.*" The significance of the last term has been before explained.

In 1671, Wepfer, in a letter (Miscellan. Nat. Curios.) addressed to the government of Wurtemberg, first distinctly pointed out lead in wine, as the cause of colic, heretofore called epidemic; and other writers of that period, Sydenham, Van Helmont, Willis, Baglivi, &c., noticed lead colic in their various works.

It is, however, the eighteenth century that is distinguished by the number and value of treatises on lead colic, though sometimes that was called by another name. Their authors have contributed to the previous stock of knowledge, and their labors have shed new light on the history of lead colic. Passing by the names of Bianchus, Calmeth, Van Zest, and even Boerhaave, we come to Henkel. This author, in his "Pyrotologie," describes the diseases to which lead founders are subject, and distinguishes carefully the processes most liable to induce that form, to which he has given the name of Founders' colic. He has the merit of proving by experiment, that lead and its compounds are the sole substances which produce lead colic, but all his descriptions of this disorder are mere repetitions of the masterly delineations of Stockhausen.

Dehaen in 1745 produced a dissertation on "*Colica pictonum*," which he followed by two other memoirs on the same subject; (*Diss. de Colica pictonum, in ratione medendi*, t. 1. — *De Colica pictonum*, cap. 11. t. 11. — *De Colica pictonum*, t. v.) These tracts of Dehaen are very able, let critics say what they may. No where in preceding times can be found so full, so exact an account of lead colic, as in the works of this Venetian physician. In the legitimate etiology of this affection he may be inexact, but let posterity accord to him the merit of having done much, and the praise of having done that well.

About this period Huxham gave an account of a disease which appeared in Devonshire, England, whose symptoms were identical with true lead colic, (*Huxham on Fevers*, 1745.) Many English physicians and chemists, by numerous and conclusive experiments, proved this disease to be caused by lead in cider of that country, derived from the press and implements used in its preparation. The Disputations of Haller contain several papers where authors adopt this view, and Illsman gives a general view of the effects of lead on the system, and an exact, but not very clear account of lead colic.

Astruc, in a treatise which created great interest on its appearance, endeavored to show that lead colic is only rachialgy. This work is a tissue of theories and is quite undeserving the praise which was at first lavished upon it. He advised venesection for its cure.

Similar views must be given of the treatise, equally celebrated, of Dubois. Its style is dogmatical, and its author, without a careful observation of facts, attributes to copper the effects of lead. But physician, as he was, to the Hospital of Charity, he praises the mode of cure there adopted in lead colic, being wholly opposed to the views of Astruc.

The work of Stockhausen, already mentioned, was translated into French about this time, accompanied by judicious notes by Gardane, who also published, in 1768, *Recherches sur la Colique métallique*, containing a succinct account of the works of the ancients on this disease. Gardane's tract contains a list of the patients affected with lead colic, who entered the Hospital of Charity from 1755 to 1767.

But the most philosophic and the most exact analyses of the symptoms of lead colic, appeared in the papers of Bonté, published in the medical journals of the period, to which our attention is now turned; and especially in the *Ratio Medendi* of Stoll. This is a work worthy the high reputation of this great clinical physician. Stoll affirms that lead alone is the cause of that colic which bears its name, and after describing minutely and lucidly its symptoms, he recommends opiates, sometimes combined with emetico-cathartics, for its cure.

Luzuriaga, a celebrated Spanish physician, published in 1796 a dissertation on the colic of Madrid. This he attributes to the adulterated wines and copper tinned cooking vessels used in Spain. Lead was derived from these sources, producing all its

usual morbid effects. At a later period, Thierry, Larrey, Coste, Pascal, published memoirs on the colic of Madrid, which they do not think caused by lead, although the symptoms which these French authors describe, appear to be perfectly analogous to those of legitimate lead colic.

The name of Dubois, noticed among the writers of the middle portion of the eighteenth century, must not be confounded with that of Desbois de Rochefort. Physician to the Hospital of Charity, and enjoying rare opportunities for observation, this acute writer has left to posterity his precious remarks on lead colic, in the second volume of his *Materie Medicale*.

And now having in this rapid survey arrived, as may be said, at our own time, the first name among authors on lead colic, is, that of Merat, who published in 1804, a *Dissertation sur la Colique metallique*, (*Theses de la Faculté de Medicine de Paris*.) Still later, in 1812, Merat, rich in numerous new observations, published his *Traité de la Colique metallique*, a work worthy the high praise which has been accorded to it. His descriptions are founded on facts noticed at the bed-side, with severe caution and accurate observation. M. Andral, in his *Clinique Medicale*, reports twelve cases of lead colic, and other lead diseases, followed by those philosophic critiques, which shed so much light on all subjects discussed by this celebrated author.

Among the many theses on lead colic, submitted to the Medical Faculty of Paris during the present period, two are worthy of especial and honorable mention. The dissertation of Canet, (*Theses de Paris*, 1823, No. 202,) contains valuable remarks on the administration of large doses of lead to animals. Colic does not ensue, but inflammation. The attempt is made to show the inflammatory character of lead colic, and the advantage of the antiphlogistic treatment. The work contains excellent observations, aside from the author's explications.

In the thesis of M. Grisolle, (*Essai sur la Colique de plomb*, 1835, Paris,) he has attempted, from about fifty cases of colic among white lead workers, to apply the numerical system to the description of each symptom, and to other parts of the etiology of this affection.

CHAPTER III.

CAUSES.

LEAD and its different compounds, must penetrate into the system, to cause lead colic, a disease consisting in a special change in organs, at a greater or less distance from the point where these preparations were primarily in contact. These substances, when deposited upon a part of the body, are taken by the capillaries and carried with the blood to the abdominal organs, whose functions are changed in a certain manner.

The animal system can only absorb bodies reduced to a molecular state, or to particles. Lead preparations, in order to be absorbed so as to produce colic, and other lead diseases, before penetrating into the system, must be previously dissolved in a liquid, or else reduced to very fine atoms, or to vapor.

Preparations of lead are more or less soluble in various liquids, mineral, vegetable, and animal. They are easily reduced to very fine, light powder; easily disseminated in the atmosphere, especially by currents of air. Lead compounds are not, when uncombined, easily volatilized in free air; metallic lead appears to be somewhat susceptible to experiencing this change. But they may be volatilized, that is, disengaged under the form of more, or less dense vapor, when they are exposed in certain circumstances to currents of gas or steam. In this case, the dispersion of lead particles in the air takes place by the aid of a volatile vehicle.

Sometimes expressions, employed in science, do not clearly express the idea. Thus, originally the word *volatile*, meant all bodies lighter than, and which could be disseminated in air, yet retaining their original solid state. The expression volatilization, is therefore now changed from its proper sense, and, in chemistry, signifies the transformation of a solid or liquid body into vapor; consequently the word *volatilize* does not indicate solid particles of lead disseminated in the atmosphere in a pulverized state.

The particles disengaged from preparations of lead, under the form of a more or less fine dust, or vapor, have received the name of *emanations*.

Solid or gaseous lead particles, in contact with the membranes of absorption, must, like all other substances, be previously dissolved by organic liquids before they can be absorbed. It is only by absorption that particles of lead cause lead colic. This is what so much distinguishes this disease from inflammation produced by the ingestion of a great quantity of lead preparations into the stomach. In this last case, the lead is not absorbed, it irritates the membrane with which it is in immediate contact, then inflames, and finally destroys it. This which comes under the class of lead diseases, caused by irritating or corrosive substances, need not here be discussed.

Lead, and all its compounds and alloys, appear capable of causing lead colic; at least, this is true of all lead preparations, that have ever been placed in contact with the organs of man.

Some writers have denied that metallic lead can produce colic. This assertion is contradicted by very numerous facts. It would be very surprising if lead did not occasion colic, when all substances into which it enters, no matter in what combinations, are liable to produce this disorder. Metallic lead very seldom occasions colic, because it is not so often as its other compounds reduced to emanations, or its particles disseminated in the air, which is the most favorable and nearly indispensable condition for the development of colic in workmen attacked by this disease.

Although lead sometimes penetrates into the system in the metallic state, yet perhaps before being absorbed by the capillary vessels, it is transformed on the mucous surface into oxides, salts, &c., in a word, into a soluble body; for the liquids of the system do not appear able to dissolve it when in a metallic state. In general, when a soluble oxide or salt with an insoluble metallic base, produces a disease, the base can be precipitated; the effects of the poison are neutralized, which leads to the opinion that certain metals, such as copper, &c., are not poisons, but that their compounds alone possess deleterious properties. Hence metallic lead, before being absorbed, and causing colic, is previously transformed into oxides or salts on the mucous surface of contact, at the expense of the humors which lubricate them.

It has been generally believed, even in these later times, that lead particles caused colic only when absorbed by the surface of the skin, and the mucous membrane of the respiratory and digestive organs. Hence, workers in preparations of lead, or

individuals, total strangers to these professions, may be in contact with particles of lead without being affected with colic.

MODES OF ABSORPTION OF LEAD IN INDIVIDUALS UNCONNECTED WITH
THE LEAD TRADES.

Cutaneous Absorption.

The slight activity of cutaneous absorption, and the doubts of some physiologists as to the absorbing faculty of the skin, indicate that lead can with difficulty penetrate into the system in this mode, so as to produce lead colic. Yet, although the epidermis may be compared to a varnish which covers the whole body, and preserves it from too sensible contact with exterior agents, it is very certain, on the other hand, that it is pierced with an infinite number of little openings, which allow the exit of the products of exhalation, such as the perspiration, and the entrance of a great number of pulverized bodies, liquids, and gases. It is known that mercury, alcohol, opium and ether, applied by friction, find no invincible obstacles in the epidermis, and that these substances, absorbed in these circumstances, have produced effects in parts at a greater or less distance from the point where they were applied. These facts should demonstrate that the skin has the faculty of absorbing lead preparations. In short, a great number of authors have proved, by examples that they have reported, the possibility of the appearance of colic, in consequence of the cutaneous absorption of lead.*

What credit can be given to these assertions? They are destitute of every kind of detail. The judgment or opinion of the author, the exactness of which cannot be verified, is given, but no complete description of the state of the epidermis and other antecedents, as symptoms of the aforesaid colic.

Desirous of verifying the exactness of the preceding facts, or rather of the assertions made by authors of preceding, and also

* Tanquerel quotes the remarks of Conringius to Stockhausen, on the effects of friction with litharge. The whole being a mere recollection of a supposed case of lead colic, which happened ten years previous, viz., in 1639, is considered doubtful. Two other cases are quoted, one from Widekind, where colic was produced by lead plaster; the other from Von Brambilla, (Mem. de l'Acad. Josephine, 1787,) where colic was caused by the use of cosmetics containing litharge. — S. L. D.

of our own times, numerous researches have been made by Tanquerel to test the question, whether lead in contact with the epidermis could cause colic.

Every day, in the practice of surgeons at the Paris hospitals, great use is made in fomentations, or simple external application of Goulard's extract, (a solution of sub-acetate of lead,) and yet the surgeons have all affirmed, that they *never* observed lead colic in consequence of these applications upon the skin when covered with its epidermis. The same fact is proved in relation to the use of diachylon plaster. This result is confirmed by the testimony of physicians in Paris of great experience; colic, from the use of topical remedies, which contain preparations of lead, is unknown in their practice and observation.

Actors who daily use cosmetics, in which white lead and minium are ingredients, to give the face certain bright colors, are not affected with lead colic, at least this is what the physicians of the Paris theatres assert; and the fact is confirmed by special inquiries of actors and actresses in relation to this question.*

But it may be said that in all these cases the preparations of lead did not produce lead disease, because they were applied to the skin in such small quantities; but this objection falls of itself, as it is known that a few grains of acetate of lead, when introduced into the system, are sufficient to produce colic. If lead is absorbed in these circumstances, which it is difficult to prove, it is in too weak a dose to cause diseases.

Tanquerel attempted to produce colic in two dogs and a rabbit by applying different preparations of lead on the epidermis. After shaving the inside of the thighs of a dog of the medium size, in perfect health, he rubbed those parts with a pomade composed of one ounce of white lead and one of animal fat. For eight consecutive days he rubbed those parts with the same pomade four times a day. Thus, one drachm of carbonate of lead was each day applied to the skin; the animal continued to eat as usual, and appeared perfectly well. The parts rubbed, placed in contact with a solution of sulphuret of potash, became black.

* Orfila, (*Toxicol.* t. 1. *edition quatr.* 1843,) quotes a case of lead disease, colic, and paralysis of the eye, muscles of the neck and hands, with great emaciation, and other symptoms, peculiar to lead affections. The case is reported by Krimer, (*Archives gener. de med.* tom. xxix.) and it is by him attributed to the use of a cosmetic containing lead, which was applied to the face, neck, and arms. — S. L. D.

To another dog, Tanquerel applied lead plaster, (diachylon,) as large as the hand, upon the stomach previously shorn. The plaster was kept in place by bandages and compresses passing round the body. After seven days, not seeing any appearance of any disease, he placed a plaster of lead ointment on the skin of the breast also shorn; this application was continued twelve days, but no change in the health of the dog was observed.

Lastly, on a rabbit were tried frictions on the back and inside of the thighs shorn of hair, with a pomade composed of one ounce of litharge, and one of animal fat; there was no appearance of any symptom of colic. These frictions were repeated three times a day for twelve days, as long as the pomade lasted. At this time the thighs of the rabbit being plunged in a solution of sulphuret of potash, became black.

In view of such facts, some positive, others negative, what confidence can be placed in simple assertions made by writers of past centuries, that lead in contact with the epidermis occasions lead colic? They are outweighed in the balance by numbers of negative facts, observed with much care by enlightened men, living in an age when every thing pertaining to observation is practised with a severity and exactness never thought of by preceding writers.

It may then be concluded, that the epidermis is an obstacle to the absorption of lead applied directly to the skin, or at least to the absorption of a sufficient quantity to cause colic. If colic cannot be produced by the absorption of lead placed on the surface of the epidermis, it seems that it may appear when this membrane is accidentally abraded or removed.

The following observations render this opinion probable. Percival, (*On Poison of Lead*,) reports several cases of colic from the application of Goulard's extract to scalded parts. Sir G. Baker observed a case of lead colic from the use of lead cerate on the denuded cutis. Duchesne, (*Thèses de Paris*, 1827,) witnessed similar facts, and Taufflieb, (*Gaz. Med.* 1838,) has described a case of lead colic produced by the use of the enormous quantity of forty-four square feet of lead plaster in eleven weeks.

In the cases of colic observed by Percival, Baker, Duchesne, and Taufflieb, preparations of lead have been applied to the skin deprived of the epidermis. Physiological and pathological experiments have proved that all substances applied to the skin destitute of the epidermis, are easily and quickly absorbed. (See

Lead Paralysis, art. Strychnine.) It is then probable that in the cases reported by the above named authors, colic was clearly manifested.

A great distinction must be made between lead applied to the skin when covered with epidermis, and when deprived of it. In this latter case, no one can find any difficulty in admitting the possibility of colic appearing, in consequence of the absorption of a large quantity of lead particles placed in contact with the cutis. This distinction, not sufficiently noticed by authors of preceding centuries, has probably caused some of the diseases produced by the application of lead on the mucous surface of this membrane, to be considered as colics produced by the cutaneous absorption of lead.

Absorption by the Ocular Mucous Membrane.

Tanquerel witnessed with Sabatier, of Orleans, a case of lead colic and arthralgy, caused by using collyria, containing preparations of lead, for the purpose of curing double chronic blepharophthalmia. In one of these, half a drachm of acetate of lead was dissolved in four ounces of liquid, and was entirely used in five days; then a collyrium of a like quantity was used in six days; on the twelfth day lead diseases appeared, first in the stomach, then in the lower limbs; the collyrium was then discontinued. Lead colic and arthralgy were cured by the use of croton oil and sulphur baths; the diseases disappeared the seventh day after using these medicines.*

Absorption by the Digestive Organs.

In the early ages of medicine, when the attention of physicians was for the first time fixed on lead colic, this disease was only observed in consequence of the direct introduction into the digestive organs, of lead preparations. It is not then surprising, that this ancient and early observation in traversing centuries, which have strengthened it with new facts, has come down to us; and a great many practitioners regard the absorption of lead by the surface of the digestive mucous membranes, as the common and even the only circumstance which can cause lead colic.

* One case only of lead colic came under the notice of Tanquerel, which he can attribute to an absorption of lead from the injection of Goulard's extract into the vagina.

Certainly the mucous membrane of the digestive organ offers a surface for the absorption of lead particles. What physiological experiments have taught us of the absorbing power of this tissue, is corroborated by the numerous examples which have been observed, where lead preparations in contact with it were quickly absorbed, and followed by the development of lead colic.

Chomel (*Dict. de Méd.* t. viii.) has reported the case of a person who took twenty-four grains of acetate of lead for some weeks, when acute colic was manifested. Fizeau (*Rev. Méd.* 1824) has given the history of a case of colic from taking several grains of acetate of lead per day. The disease occurred in about a month after commencing the use of this substance. Fouquier prescribed to an invalid a pill containing only one grain of acetate of lead. After the use of one pill only, slight colic pains were produced, and on the repetition of the dose, decided colic was declared. Suspicions were awakened that all was not right, but Devergie by chemical analysis found only one grain in each pill, (*Devergie, Lég. Méd.* t. ii. 2^e partie.) Tanquerel prescribed acetate of lead to a patient, who took one hundred and thirty grains in fourteen days, when lead colic occurred. This having been cured, the same patient took, in a few weeks after, one hundred and forty-nine grains of acetate of lead in sixteen days. Colic then supervened and proved fatal. Ruva (*Gaz. Méd.* 1838) has observed colic produced by the ingestion of ten grains of lead shot. The fact that lead, exhibited as a medicine, does not always cause colic, proves only that all individuals are not alike susceptible to its effects. Formerly, lead was much more often given as a medicine than at the present time; hence lead diseases were more common then than now, from the use of lead preparations.

Lead preparations administered internally as medicines, in a liquid or solid form, have sometimes been followed by well marked colic. Tanquerel is persuaded, that preparations of lead introduced into the digestive organs, as medicine, occasion colic more frequently than is generally believed. He has seen these substances administered four or five times only, and twice colic and other lead diseases appeared. Ventral diseases consequent on swallowing these medicines are not noticed, or commonly these are attributed to the disease, for the cure of which, lead was administered; thus very often lead colic appears under these circumstances, and probably passes away unperceived. Tan-

querel has himself, for some days, misunderstood lead colic, caused by lead injections into the vagina. It is reasonable then, he thinks, to believe that other observers have not always recognised colic, caused by the internal administration of lead as medicine.

Lead colic has been observed in persons who have taken food containing different preparations of lead. Thus some physicians have met with this disease in persons who had eaten bread made with meal, in which white lead was mixed; (*Gmelin. Apparatus Medicaminum*, vol. i. 1760.)

Many cooking utensils, especially those made of copper, are lined with an alloy composed of a great quantity of tin and a very small proportion of lead. When this tin coating is new and well made, it does no injury. But when, from long use, it is partly worn, particles of this alloy may mix with the food and cause serious diseases, such as colic. Barruel mentions in his report that sausages,* dressed in a copper kettle lined with alloy, produced severe symptoms of abdominal poisoning, owing to the particles of oxide of lead derived from the coating; (*Annales d'Hygiène et de Médecine légale*, vol. x.)

Sometimes diseases produced by utensils covered with alloy, are not marked by lead colic. Gastritis and enteritis show the introduction of a great quantity of lead into the stomach, or the mixture of particles of lead with other poisonous substances, such as oxide of copper.

Even when the alloy is new, if badly prepared, it may occasion colic. The experiments of Vauquelin and many other chemists, seem to show that new alloy, where the proportion of lead is only ten hundredths, cannot cause any disease, the quantity being too small to be attacked by acids. Truly these acids may attack the tin only of this alloy, which being much more oxidable than lead, takes all the oxygen arising from the acids.

On the contrary, all alloys of tin and lead which contain a large proportion of the last, may cause diseases, among others, colic, for lead is easily attacked in contact with solids or liquids containing, naturally or accidentally, free acids. Thus fruits, vegetables, fish or seasoned meats, dressed in vessels tinned with a very large quantity of lead, occasion colic. Vinegar, especially, easily attacks lead, with which it forms an acetate.

* Chitterling.

In 1775 a violent and peculiar colic prevailed at Rochelle, whose symptoms so perfectly resembled those of lead colic, that Senac suspected it was owing to an alloy composed with a great proportion of lead which the inhabitants of the city used. They abandoned the use of vessels thus tinned, substituting for them another composition, and the colic disappeared.

To a like cause, Luzuriaga, and Hernandès attributed the frequent development of lead colic formerly at Madrid. Since law in many countries has fixed the minimum quantity of lead to be used in tinning, colic is rarely produced by food prepared in tinned copper vessels.

Formerly, in certain countries, food was cooked in leaden vessels. It can easily be conceived that such cooking utensils must cause colic, even more easily than those lined with alloy of which lead forms a large proportion. The use of lead for cooking vessels, has therefore been abandoned.

Writers in the eighteenth century mention a great many cases of lead colic, epidemic in its form, produced by the use of wines adulterated with litharge, or white lead, for the purpose of rendering sweet and agreeable, those that were sharp and harsh. This fraud was then generally practised and occasioned so many diseases, in Germany, Italy, and France, that the governments of those countries were obliged to publish several ordinances, in which they declared that the greatest severity would be used against persons who permitted such deceptions. Zeller relates, that a publican was condemned to death, because he had caused an epidemic lead colic in a village in Germany, by sweetening his wines with litharge. This unfortunate person was himself attacked with this disease.

Before the discovery of this fraud, which was practised for a very long time, it was supposed that colic was produced by harsh and sour wines. But since measures were taken by government to discover the fraud, epidemic colic caused by harsh and sour wines is not seen, as in the time of Paul of Ægina, Citois, &c., and medical works contain numerous records of colic from this cause.

Warren, in his work on Poitou colic, reports thirty cases of persons in the house of the Duke of Newcastle, in Hanover, who were attacked with lead colic from having used white wine, adulterated with preparations of lead. Many of these persons experienced for years fresh attacks of colic. Others were taken

with delirium, and frequent epileptic attacks, which brought them to the grave; finally, energetic purgative treatment cured the greater part of these colics, (*Trans. Lon. Coll. Phys.* vol. ii.)

In 1810 the Commissary of Police at Versailles was informed that the wine which was sold at a certain place caused very severe colic in those who used it, and that many had fallen victims to it. M. Tessier, physician at the hospital in that city, was desired by the authorities to make a report, if possible, on the cause of this disease. An analysis of this wine detected one grain of acetate of lead per bottle, a quantity sufficient to account for the serious phenomena in persons who had drank this poisoned wine. In fact, the seller frankly confessed having added to half a pipe two ounces of litharge. Leroux mentions (*Cours de Médecine*, vol. ii.) a wine merchant who was attacked with lead colic from using wine which he had adulterated with litharge. He was even affected with lead paralysis of the fingers and wrist.*

The wines used in Paris, and every where in France, were, so late at least as 1837, submitted to frequent visits from *tasters* capable of easily detecting the presence of the smallest quantity of lead preparations in this liquor. Hence, few venders incurred the risk of the penalties prescribed for adulterating wines with litharge. A most skilful taster, in twenty years' exercise of his profession, met this fraud three times only, and lead colic produced by wine so poisoned is now quite unknown.† Some persons who drink wine, beer, cider, or alcohol, prepared, collected, or kept in lead vessels, are attacked with lead colic.

The wine which is spilt in measuring on the lead counters of wine venders in Paris at length attacks the metal. At last, by the continued contact of atmospheric air with this metal, particles of acetate of lead, or oxide of lead, are formed, and mingle with the wine. Persons who buy this wine, containing lead, are

* Pure and unadulterated wine has a slight action only on lead, and probably the very small quantity which would be dissolved would be precipitated by any free tartaric acid. It has been observed, that new rum often contains lead, derived from the still, while this same rum, after being some time in cask, affords no trace of lead. Dr. Traill explains this fact by the precipitation of the lead by the tannin of the cask. — S. L. D.

† A case, however, is reported to have occurred in Paris in 1840, (*Ann. d'Hyg. et Méd. lég.* t. 31.) — S. L. D.

sometimes attacked with lead colic; many physicians have observed this, among others, Leroux.*

Musgrave and Huxham attributed to the use of sour and sharp cider a disease similar to lead colic, that they observed in their time, in Devonshire, England.†

The history of the labors of Sir George Baker, to prove the identity of Devonshire and lead colic, is too well known to be here repeated; suffice it to say, that he not only proved the presence of lead in Devonshire cider, but traced that to the use of lead about the mills and presses in that country, and to the fact that the farmers were in the habit of introducing a bit of lead into the cider cask to retard fermentation, (*Trans. of Coll. Phy. Lond.* vol. i.) ‡

Van Swieten has seen a whole family attacked with lead colic, from having used, in the preparation of their food, water, which had remained in a lead vessel. (*Ed. lat.* 1766, vol. iii.) Tronchin has endeavored to prove, that lead colic, so common in his time among the inhabitants of Amsterdam, was caused by their using rain water, which had remained in cisterns lined with lead, or upon the flat roofs of the houses, which were also covered with the same metal. Van Troostwyk has also observed that the waters at Haarlem, collected in the same way as those of Amsterdam, occasioned the same diseases. (*De l'Electricité Médicale appliquée à la Médecine*).

* It has been noticed in England, that lead colic has been produced by lead covered counters in quite a different class of dealers, viz. fishmongers. — S. L. D.

† It is the opinion generally of chemists, that malic acid forms an insoluble, salt with lead, but the recent experiments of Chevallier and Ollivier, (d'Angers,) have established the contrary, (*Ann. d'Hygiène*, No. 53) — S. L. D.

‡ I have several times examined cider used in this vicinity, which had produced disorders, with vomiting, griping, or great nausea. In some cases this did not appear till the barrel was half consumed. The presence of acetate of lead was always detected, and its origin traced to composition faucets used for drawing out the cider. Hence the symptoms of lead disturbance appeared not immediately on tapping and drinking the cider. But as the lead cock was dissolved, persons who before had not drank the liquor were easily affected. In one case, where no metallic faucet had been used, the cider was largely impregnated with lead. The history of the vessel being traced, it was found to have been formerly a wine cask. This is the only instance within my knowledge which has occurred to authorize the suspicion that wine imported into this country may be occasionally adulterated with lead. I have frequently examined wine, but have never detected in it lead in any form. — S. L. D.

Wall has seen all the residents on a farm attacked with lead colic, from drinking water from a pump, the reservoir or cistern of which, and the pipe, were lined with lead. This metal, in the course of three years, was known to have been in a great part destroyed and mixed with the water. By the advice of Wall, the farmers used other water not in contact with lead; from that time they were not attacked with colic. (*Trans. Coll. Phys. Lond.* vol. iji.)

It is easy to account for the development of colic in these circumstances. Lead, exposed to moisture, is easily transformed into oxide, then into carbonate of lead, by the oxygen and carbonic acid of the air. The sub-carbonate, thus formed, is wholly, or partially, dissolved in water, by means of the carbonic acid that it generally contains in excess. Thus in cases where water remains some months* in lead cisterns, a white line may be perceived at the top of the water, which remains distinct when the latter diminishes; this white line is carbonate of lead. Six loads of water† left for two months in a pneumatic cistern lined with lead, having been analyzed by Merat, gave more than two ounces of super-carbonate of lead, very well crystallized.

Is it then surprising that the inhabitants of Amsterdam and Haarlem suffered from lead colic, in consequence of using water containing carbonate of lead?

But water not in contact with air generally effects no change on the lead in which it is contained. It is partly through pipes of this metal that water is distributed in different public and also private establishments in Paris, and Tanquerel has never learned that water thus conveyed has caused *lead colic*. Water circulating in these lead pipes is not in contact with atmospheric air, therefore, carbonate of lead, can, with difficulty, be formed. He repeats, "with difficulty," for the water which passes through these lead pipes most frequently comes from springs, which are generally very much charged with carbonic acid and carbonate of lime, and until this last salt covers the inside of the conduit, carbonate of lead is formed and dissolved by the excess of carbonic acid which the water contains. So the inhabitants of some cities, establishing fountains, have suffered with colic from

* Or even for a few hours. See Appendix on Lead Pipe, &c.—S. L. D.

† This is very indefinite, "*six roics*" Christison estimates at about 1000 lbs.—S. L. D.

using the water which first passed through the new pipes, Alph. Devergie, *Méd. lég.* tom. iii.)

Sometimes children, or grown persons, have been attacked with lead colic from eating bonbons colored yellow, green, blue, or red, by different preparations of lead. Especially at the season when these dainties are eaten in greater abundance, e. g. New Year's day, (*Annales d'Hygiène et de Médecine légale*, tom. i. iv. vii. x.)

Many times, without doubt, when physicians cannot account for disorders in the digestive organs of certain children under their care, they are caused by the use of these poisoned bonbons. Chromate of lead is used to color bonbons yellow, green, and blue, minium to color them red. Confectioners prefer these metallic to vegetable preparations, because they are fast colors. Chemical analysis has always discovered compounds of lead in bonbons thus colored, which have caused colic, (*Ann. d'Hyg. et de Méd. lég.*)

Candy bonbons are not, like those just described, colored in the mass with preparations of lead. Confectioners are contented with applying to the outside, with a pencil, white lead or silver, in different designs. Sometimes white lead is so freely applied, that the surface, scraped from one of these bonbons, has given a grain of lead, and colic has been developed in children who have eaten them, (*In loco citato.*)

Almonds, sugar plums, &c., are also often colored with preparations of lead, and their use may be followed by accidents.

The papers used for wrapping bonbons of all kinds are painted with lead preparations to give them bright and agreeable colors. Children often suck or eat these papers, producing more or less serious diseases, such as colic, &c. These papers are generally colored with carbonate or chromate of lead, or Naples yellow. (Andral, *Ann. d'Hyg. et de Méd. lég.* tom. iv.)

Lead foil is used by the manufacturers, to cover chocolate and similar substances; if these objects are placed in a moist situation, oxide of lead forms on the surface of the paste, which is very hygrometric, and soon penetrates to the inside. Such food is capable of producing colic.

The use of playthings for children, colored with preparations of lead, intended to be placed in the mouth, such as trumpets, have caused serious diseases, among others colic. (Baker, *Trans.*

of *Coll. Phys. London*, vol. ii. *Rapport sur les travaux du Conseil de salubrité de Nantes pendant 1829.*)

Absorption by the Respiratory Organs.

Individuals who do not work in lead, are rarely attacked with colic from breathing particles of lead, as they are seldom in situations where the mucous membrane of the respiratory organs comes in contact with lead emanations.

Persons who have been affected with lead colic, from sleeping in newly painted apartments, evidently absorbed by the mucous membrane of the respiratory organs, the lead emanations proceeding from these paints. Leroux and Louis have reported cases of colic in persons who slept one or more nights in newly painted rooms.*

Gardane reports that he had frequently observed lead colic in naval officers, because they often, on board their vessels, lived in newly painted rooms, which constantly exhale abundant lead emanations. There is no place on board, intended for the chief officers, which is not more or less infected with emanations from the paint. Hence it is easy to explain why the sailors who sleep between decks are exempt from it, and why those who are most sedentary, are most frequently attacked (*Ancien. Journ. de Med.* 1784). M. d'Argenvilier, aged sixty years, of a nervous temperament, living near Mantes, was taken in 1822 with pains in the stomach, which, at intervals, became much more severe, and diminished by pressure. The abdominal parietes were retracted, there was obstinate constipation. The patient was restless, especially at the time of the attack, then he groaned aloud, constantly changed his position, writhed in his bed, &c., his sleep was light, and he was anxious. After fifteen days' suffering his strength began to fail, he became thin, &c. The physicians who attended M. d'Argenvilier tried different remedies, such as narcotics, baths, cataplasms, mollifying embrocations. These afforded no relief, he remained in this state forty-five days. Despairing of his case, he went to Paris to consult Lerminier, physician at the Hospital of Charity, who, after an attentive examination, told him his disease was painters' colic; and inquired

* Taylor (On Poisons in relat. to Jurisp.) relates that he had experienced, in his own person, the bad effects of sleeping in newly painted apartments. — S. L. D.

how this colic had appeared. The patient said, he was having some painting done in his country house; he went from time to time to see the work, and slept in a newly painted room. After hearing this, Lerminier subjected him to the treatment practised at the Hospital. In a few days he was cured, returned to the country, and soon resumed his usual occupations. After this M. d'Argenvilier never slept in freshly painted apartments, and never approached very near painters when at work. He has not again been attacked with this disease. (*Observations communiquée par M. Maigne, Médecin en chef des Hospices de Mantes*).

In 1837, De Corsin, residing at Vilette, near Paris, after sleeping two nights in a chamber newly painted with white lead, was attacked with all the symptoms of lead colic. After suffering some days in the stomach, the disease spread to the brain, attacks of epilepsy followed, and preceded alternately with delirium and coma (lead encephalopathy) appeared, and speedily brought the unfortunate man to the grave. (*Journ. de Med.*)

Tanquerel has observed colic in circumstances similar to the preceding. In 1836, when a great many house and ornamental painters, who used spirit colors for the cornices and wainscots, were employed in the halls of the museum at Versailles, the gilders of wood, who do not use an atom of lead, were at work in the same room, and at the same time as the painters. Whilst they were engaged in this work, they had orders to closely shut all the windows in each room. After a few days' working in this manner, the gilders were troubled by the insupportable smell of paint and spirits of turpentine, which caused lead colic in twelve of them, and also in several of the painters. Opening the windows of these rooms prevented the smell of paint from being so strong, and colic did not again appear among the gilders.

Leaves or boxes of lead used in trade for containing snuff may have a deleterious action on the health of individuals who use this powder. Certainly the action of snuff on lead is very speedy. (Remer, Seberer, Hofheine). It begins after a few hours. It forms acetate, carbonate, and hydrochlorate of lead, from six to thirty grains per pound. (Chevallier *Journ. de Chimie Médicale*, 1831).

It may, then, easily be conceived that persons who use snuff containing these salts, from the absorption of lead by the surface of the mucous pituitary membrane, will be attacked with

diseases such as colic. This is established by Guyton de Morveau and Chevallier.*

Several experiments have been made upon animals, for the purpose of producing lead colic, from the contact of lead preparations with the mucous membrane of the respiratory organs.

All these experiments seem to prove that lead preparations in contact with the mucous membranes which cover the digestive and respiratory organs are easily absorbed, and lead colic is often developed in consequence of this absorption, whilst the skin covered with its epidermis, in contact with lead, does not absorb a sufficient quantity to produce colic.

OCCUPATIONS WHICH CAUSE LEAD COLIC.

There are actually but few cases met with in practice of colic caused by lead introduced into the system, in the circumstances that have been above noticed. This infrequency of colic arises from the slight use made in these times, of lead preparations in medicine; in the adulteration of food, drink, &c.

Generally, the persons who suffer from colic are those who prepare lead for the arts: Therefore a particular study was necessary, of the operations employed in the different occupations which cause colic, by introducing lead into the system. By this investigation, the modes, by which lead preparations enter the system and cause disease, have been discovered. Preparations of lead are used in an infinite number of the arts, and are so essential, that they cannot be replaced by harmless substances. It is not then surprising, that lead colic is a very frequent disease, in great, industrial and artistic cities like Paris.

In short, nearly all the occupations in which lead is prepared for the arts and industry, may produce colic. Any one who visits, at Paris, those persons who work in lead or its compounds in any way, may be assured of this. Accounts from other countries, where they pursue occupations in which lead is used, and

* Prof. Otto reports two cases of lead disease which arose from lead in Macuba snuff, in Copenhagen, in 1842. These cases excited great interest, from the character and position of the sufferers. In one, the usual primary effects of lead were observed, followed by colic, and encephalopathy. The disease proved fatal in four months. The snuff was found to contain 16 to 20 per cent. of red lead. (Chemist. vol. iv).—S. L. D.

which do not exist at Paris, (the number of which is considerable,) confirm the general proposition just made, and which will be proved in the course of this work.

TABLE

OF THE OCCUPATIONS OF 1213 INDIVIDUALS AFFECTED WITH COLIC.

All but nine of these were inmates of the Hospital of Charity. All were cases observed by Tanquerel.

OCCUPATIONS.	
Manufacturers of White Lead,	406
“ Minium, (red lead,)	63
“ Mineral Orange,	19
Painters of Buildings,	305
Carriage Painters,	47
Ornamental Painters,	33
Painters on Porcelain,	3
Gilders on Wood,	1
Painters, or Varnishers of Metals,	2
Paper Stainers,	2
Grinders of Colors,	69
Manufacturers of German Cards,	13
“ “ Glazed Cards,	6
Makers of Military Belts,	2
Perfumers,	2
Manufacturers of Earthen Pottery,	54
“ “ China Ware,	7
Refiners,	25
Plumbers, and Sheet Lead Makers,	14
Platers, (in tin and lead,)	8
Manufacturers of “ tin putty,” (<i>tin potée</i>) used for polishing,	4
Workers in Tin,	4
Jewellers, Goldsmiths and Manufacturers of Toys,	4
Copper Founders,	2
Bronze Founders,	1
Type “	52
Printers,	12
Manufacturers of Shot,	11
Lapidaries,	35
Cutters and Polishers of Crystals,	3
Laborers in Glass Manufactories,	2
“ “ Manufacturers of Acetate of Lead,	4
“ “ “ “ Nitrate “ “	3
“ “ “ “ Carbonate “	3

Total,—1213

TABLE

Of Occupations not mentioned in the preceding Table, and which have caused Colic.

Laborers in Lead Mines,	Manufacturers of Porcelain,
Steam Boat Firemen and Engineers,	Glass Makers,
Laborers in Manufactories of Litharge,	Enamellers,
Glaziers,	Apothecaries.

These last cases, though not observed by Tanquerel, are stated on authority on which he relies. Probably there are other occupations which rarely cause colic. Notwithstanding Tanquerel's thorough investigation, he could discover no others in Paris, or other places. Individuals of every occupation, who are attacked with lead colic are received at the Hospital of Charity; they prefer to go to this establishment, attracted by the celebrity of its ancient treatment. This is the reason why the table shows in so precise a manner, the relative frequency of this disease, considered in relation to the occupations, at Paris.

More than twelve hundred and four patients affected with lead colic, came for advice, or were received into the wards of the "Charity," during the eight years ending in 1838.

Some escaped Tanquerel's examination, but this applies indifferently to patients of different conditions. The "Charity" receives a larger number of patients affected with lead colic, than all the other hospitals in Paris together.

It would have been impossible to have formed a table like the preceding, without serious errors, if the indications furnished by the registers of the "Charity" had alone been depended on. For instance, laborers in manufactories of white lead, and minium, only work there occasionally, because they cannot, from the nature of the employment, work constantly. Hence, when these persons, the most numerous class of patients, come to the Hospital suffering from lead colic, their names are almost always inscribed on the registers of the establishment, with that of their former trades; masons, plasterers, factors, founders, distillers, sailors, soldiers, &c. In tables made from such records, one of these occupations might have been accused of producing a disease, that it never could cause. The records furnished by the "Charity" are then inaccurate, and have caused Merat and some other observers to believe that an infinity of substances, distinct from lead, may produce lead colic. This distinguished physician has not been able to produce a single observation, to sustain this position.

All the cases of lead colic among workmen seen by Tanquerel, occurred in persons who had been in some way in contact with lead. Some of them, such as workers in glass manufactories, tinmen, and copper founders, who handle principally mercury, iron, and copper in their trades, would, on the first attack, attribute the development of colic to these metals. But when these persons were carefully questioned, when their workshops were visited, Tanquerel quickly perceived that a small quantity of lead was mixed with the other substances that they used, and to which the lead disease could be attributed.

It is from want of accurate observation, that some authors have stated that copper, mercury, and iron may produce colic. These substances, worked without lead, have never caused colic resembling that produced by lead. Whenever there is a disease in the stomach, which has the same physiognomy as that produced by lead, where the cause cannot be discovered, care should be taken not to pronounce that it has no connection with lead, for by investigation it will generally be discovered that the patient has been, in some way, exposed to contact with lead particles.

A woman was received at the Hospital of Charity, who was suffering with a disease perfectly resembling lead colic. This patient said, that she had used no medicine for five or six years, had not slept in newly painted rooms, and had never worked in lead; in a word, all questions failed to discover her having been in contact with lead. This fact seemed so extraordinary to Tanquerel, that he tried every means to discover the cause of this colic; he went to the house of the patient. She lived in a little room, the floor of which was in a very bad state, with many holes in it. Immediately below this room, on the ground floor, was the workshop of a perfumer, where some pounds of white lead were ground and sifted at the beginning of each month, to mix with different cosmetics, pomades, &c. During this operation, some of the air from the under room loaded with particles of white lead, easily passed through the holes in the floor of the room where this woman lived.

It was not then surprising that, in consequence of contact with subcarbonate of lead, she was attacked with lead colic. If she had been attended by a physician who had not taken as much pains to seek out the cause, as Tanquerel did, would the disease have been recognised as lead colic? Certainly not. The phy-

sician, after the replies of the patient, would have believed himself correct in stating, that a colic similar to lead colic might be developed in persons who were never in contact with lead, and every body after him would have repeated the assertion. Thus the error would have extended from want of sufficient investigation.

A small part of the gums and teeth of this patient were covered with sulphuret of lead. This discoloration, if it had been early noticed, would have shown at once, that this woman had been in contact with lead, and that her disease could be referred to this substance, which certainly had been introduced into her system.

By inspecting the table of the various trades subject to lead colic, which has been before presented, it will be seen, that they do not all equally induce that malady. This remark would be true, even were the numbers of hands employed in each equal. The number of white lead workers, red lead makers and house painters in Paris amounts to several, probably to ten or twelve thousand. It is among these that occurs the greatest number of cases of colic. When we survey these various trades, and their separate processes, it is at once seen, that the liability to colic is greatest among those, who are employed in drying, packing, pulverizing, or mixing and grinding the various products. Indeed this view allows a classification of the workmen: 1st, those who live and work in an atmosphere loaded with lead particles; 2d, those who breathe an atmosphere of lead emanations only, or merely handle lead. In the first class are included workers in manufactories of white and red lead, litharge and other calcined oxides of this metal, makers of chrome yellow, and grinders and mixers of these preparations. The second class includes the other trades embraced in the tabular view. All the manufactories, in which work the individuals of the first class, are pervaded both by lead particles and emanations. Though not visible to the eye, yet the presence of lead in the air is detected by chemical analysis, and often it is at once noticed by the peculiar odor of lead, its sweet styptic taste, the discolored gums and teeth of the workers, and by sulphurous baths applied to their well washed skin, which then immediately darkens, showing how intimately lead is combined with that tissue.

The ancient Dutch mode of making white lead, by stacking the pots containing the metal and vinegar, with fermenting

manure, or other matters, and the modern French process of precipitating subacetate of lead by carbonic acid, and the various modifications of this last method, all induce lead colic in the persons employed, in from three days to six years after entering the manufactories. Though each step in the trades of white and red lead making is dangerous, yet some parts of the operation are much more liable to induce colic than others. The circumstances influencing this result have been pointed out. In general, it may be stated, that the result of careful observation shows, the Dutch or dry way is more dangerous than the French or wet mode of manufacture. In either, as well as in the trades of red lead, and litharge making, the processes of washing and filtering the products are least liable to induce colic. It is remarkable, that, with the exception of red lead makers, workers in other lead trades, turning white lead makers, are much more easily affected with colic than if they had not been thus previously exposed to the effects of lead. Next after those engaged in the manufacture of white and red lead, litharge, &c., painters of buildings are most often attacked with colic. This class exists wherever civilization has introduced comfort and cleanliness. And its onward march is ever followed by that unfortunate attendant, lead colic. The peculiar susceptibility of painters to colic has impressed the name painters' colic, on that form so common and so widely diffused. At least one quarter part of house painters, who have followed their trade thirty or forty years have suffered one or more attacks of colic. Some fall victims in a few days, others only after twenty or thirty years, no change having been made in their habits. It is grateful to know, however, that the greater part of painters pass through life without ever experiencing pain from lead colic. Painting has its posts of duty, more or less dangerous.

Those most disseminating lead particles and emanations are most to be feared as causes of colic. Among these are: 1st. Scraping off old paint, which diffuses lead dust. 2d. Color grinding. 3d. Painting in closed and heated apartments, or rooms where many are at the same time engaged with the paint brush.

The "spirits," the essential oil of turpentine used in the color, diffuses lead emanations by its evaporation. This fact is well established. No one affirms that turpentine itself has ever caused colic. Where, as is sometimes the case, old paint is burned off

by "spirits," there lead is diffused by its vapor. It is generally admitted that a coat of varnish prevents lead emanating from newly painted surfaces.

Painters, at present, generally purchase lead ground in oil. When they grind it themselves, that operation is the most dangerous part of their trade, for color grinders employed in this part only, handling neither brush nor color, are often attacked with colic. Indeed, no part of the lead trades is so dangerous, so liable to cause disease, as that of color grinding. Formerly the greater proportion of patients affected with lead disease, who applied at the Hospital of Charity, were color grinders. This operation produces an atmosphere charged with lead particles. The emanations, and minute, almost impalpable dust produced by breaking up the packages and masses of lead preparations, cover the workmen who breathe and swallow the lead polluted air. Humanity has called into existence many machines for mixing and grinding painters' colors, which have diminished very much the danger attendant on the process.

Carriage painters are less liable than house painters to colic, and still less liable are imitation and ornamental painters; least exposed to causes of colic are portrait and picture painters. They buy their lead basis, prepared in oil and inclosed in tin foil cases; they rarely use spirits of turpentine, which, as has been shown, diffuses lead emanations, and above all, they are generally clean and neat about their work. Formerly artists of this class prepared the colors which they used, and were occasionally seized with lead colic. Fernel reports an artist of Angers who suffered from colic, and well he might, as was justly said by a brother of the pencil, for he cleaned that implement in his mouth! Tronchin affirms, that portrait painters are attacked with colic and other lead diseases. It is not so. The premature death of Corregio and of Raphael and other celebrated artists, cannot be truly attributed to the effects of lead. They were men, liable like the common race to encephalitis, pulmonary tubercles, cancer of the stomach, prolific causes of death in persons of the peculiar temperament and habits of this class of artists. Still lead disease is happily extremely rare among portrait painters. One of this class was admitted a patient at the "Charity." All, both attending physicians and pupils, hastened to Tanquerel with news of this fact, so opposed to his observation. When, lo! it turned out, that the artist had formerly pursued the humbler department of house painting.

Paper stainers use no spirits of turpentine in their pigments; these are mixed with size and other substances, and it is only during this preparation, that the workers are exposed to lead emanations. But the after operations, following printing and drying, diffuse lead particles in the air, and colic makes its appearance among those who may be thus exposed. No bad effects are observed arising from the constant handling of the colors in the wet state. Indeed this might be inferred from the fact that dyers, calico printers and others handling moist acetate of lead, suffer not from the attacks of colic.

Even in the French mode of preparing ceruse, those whose hands are constantly bathed in solutions of acetate of lead, seldom experience colic, compared with the packers of the dry product.

Potters, including in this class the makers of the common red ware, are sometimes victims to lead colic. The glazing of this ware is produced by lead oxide. It is applied diffused in water, but this operation, in which the hands are constantly bathed in red lead, produces no injury. It is only the furnace men, who are exposed to lead vapors, who suffer among red ware potters. The colic was at no late period so rife among potters, that it acquired the name of *colica figulina*. Potters not only suffer, but their vessels also cause colic in others. The annals of science record numerous cases caused by the use of lead glazed ware; and Illsman reports that colic from this source was once so common in Germany, that several of its States published instructions for glazing without the use of lead.

This cause of colic is most often effectual from ware imperfectly baked, or fired, yet, even in well glazed vessels, fat or oil contained in the food cooked in them, often dissolves the lead glazing. Some cases are on record, where, in England, the makers of the common blue printed, or Liverpool ware, have been affected with lead colic.

The most singular cause of this malady is found in the cases reported in the *Jour. de Chim. Med.* 1838. In these, steamboat firemen and engineers were attacked, being constantly exposed to great heat, which volatilizes the lead from the steam joints, filled with packing, composed of red lead, litharge and oil.

Of the other tradesmen mentioned in the table, a large portion is composed of those persons who are constantly handling lead. Among these are sheet lead makers, who, in the operation of melting, are also exposed to lead fumes and emanations; while

the handling of old lead, frequently covered with a coat of carbonated oxide disseminates lead particles. Dealers in sheet lead, unconnected with visits to the manufactories, have had lead colic induced by frequently opening rolls, a light coat of oxide being thus detached. A few years ago, at the depot of the Royal sheet lead works in Paris, several hands who had been all day engaged in opening rolls of lead in a small room, were all, without exception, seized with colic the day following.

Tinmen occasionally suffer colic, their solder being the source of the lead; so tanners of copper, and workers of Britannia ware, type founders, and others handling lead alloys, are all occasionally seized with lead colic. These various tradesmen are designated by the general term plumbers, and anciently, the disease, produced thus by continually handling lead, was called *colica plumbariorum*. The cause being neither particles nor emanations, should induce the most scrupulous attention to cleaning the hands after work.

Among shot-makers, at least one half are said annually to experience lead colic.

Lastly, that trade without which all others would be valueless, the art and trade of printing, has given its victims to the disease, so inseparable from all forms of using lead. Among printers, the pressmen are never attacked; but some of the compositors, especially if they practise holding types in the mouth while correcting a typographical error, are not unfrequently attacked. The continual handling of lead alloy, the setting up of types detaches lead particles; and the cases of types are often found covered with a light lead dust, which is removed sometimes by the bellows, thus filling the air with poisonous particles.

RECAPITULATION OF THE DESCRIPTION OF THE CHANNELS OF ABSORPTION OF LEAD.

The sketch of the different arts and trades in which lead is used, and the greater or less ease with which the various operations cause colic, allow certain inferences, which may be stated as corollaries.

Absorption by the Digestive, Respiratory, and Ocular Mucous Membrane.

The air about the worker is charged either with lead particles, or vapor. This is produced by heat, percussion,

friction, by the evaporation of substances with which lead is mixed, as spirits of turpentine, carbonic acid, sulphuretted hydrogen, and many others. In all these cases, the mucous membrane is placed in position to absorb lead, and thereby cause colic.

The mouth becomes the great inlet to lead; its passage is denoted by the various signs which have been pointed out. Besides, the saliva impregnated with lead and continually swallowed, introduces that into the stomach. Every deglutition introduces through the mouth a portion of air, according to Bouvier, (*Bulletins de l'Athénée de Médecine*) into the digestive apparatus. The great absorptive power of the mucous membrane of the mouth is well known. Here are lead and an appropriate surface, and thus two powerful conditions for developing lead colic co-exist.

All poisons, in a state of vapor, generally pass into the system by respiration. The air, saturated with lead emanations and particles, continually passes over the respiratory apparatus, and the mucus, which lubricates that, dissolves the particles, which are thus easily absorbed. Notwithstanding the opinion of some authors, that if lead was absorbed by respiration, the lungs, and not the digestive organs, would be first attacked, and irritation be there produced, yet no well marked case of inflammation, or affections, other than those of lead, has been observed.

Tanquerel asserts confidently, that persons in the various lead trades, and especially painters, are seldom attacked with lung complaints. Among twelve hundred and seventeen cases of lead colic, fifty-five presented tubercles, of whom, fifteen out of three hundred and forty-eight, were painters.

It is difficult to decide which is the most copious channel of absorption, the respiratory, or the digestive apparatus, though Tanquerel inclines to attribute more to respiration. The mucous membrane of the eye, is a decided but partial inlet.

Cutaneous Absorption. — There are some few trades, where neither lead particles, nor emanations are produced. If colic should appear among the workers of this class, it must be admitted, that if every attention to cleanliness has been observed, the skin has absorbed the lead. But no genuine case from this cause has been noticed.

The skin, in many lead workers, is covered with lead particles; no dress keeps them off, they sift through between the clothes and the skin. Are they there absorbed? Positive observation

does not allow an affirmative answer, though, *à priori*, such absorption is possible.

It follows, therefore, from all the preceding statements,

1. That only workmen who disseminate lead particles, in the air about them, expose the mucous membrane to contact with its emanations, and contract colic.

2. But since lead colic attacks persons, not connected with lead trades, the poison here being introduced by absorption, it may be affirmed, that, generally, colic is produced only by absorption through the mucous membrane. Tanquerel has candidly confessed, that his earlier opinion, then common at the time, (1833) that the skin was also an organ of absorption, has been proved erroneous by longer and more accurate observation and experiment. This question seems now to Tanquerel to be decided.*

Interesting as it would be, to determine the quantity of lead necessary to induce colic by absorption, it can only be said, that it is different in each individual, and that this quantity has been found to vary from one to one hundred and forty grains.

In fact, individuals exposed under similar circumstances are attacked with colic at very different periods. But it is possible that they absorb continually, but as their excretions vary, the accumulation of lead will vary, and so disease manifests itself at different periods. So circumstances, whether the more free air of the house painter, or the confined and dusty room of the packers and grinders, will produce different effects.

Merat contends, that it is not essential that lead should be absorbed to induce lead colic. But rigid observation does not confirm this opinion, nor could it be true, even if chemical analysis did not trace lead in the organs; for it is well known, that many unquestionable mineral poisons, after having been introduced into the system with specific effects, have not been traced by chemistry.

Once absorbed, lead is carried by the circulation to the organs which it attacks. All efforts to discover its specific mode of action have been fruitless; it will probably be known when the action of strychnine, quinine, opium, &c., are revealed.

Lead does not necessarily produce immediate morbid effects,

* The Committee of the Royal Academy of Medicine, in their report on Tanquerel's work, 1841, consider this still an open question. — S. L. D.

it may remain inactive for a varied period, and then be roused to action, years after its introduction, and after the person has been withdrawn from contact with it; but a careful observer would have detected, all this time, the marks of the primary effects.

CHAPTER IV.

PREDISPOSITIONS.

It has already been stated in this work, that persons in contact with lead, in the same circumstances, are not all equally liable to be attacked with lead colic. It is necessary, then, to examine and discover whether there are circumstances which favor or oppose the deleterious action of lead preparations. A review of the seasons, climate, age, sex, constitution, and diet, must be taken before we can understand these different influences.

Seasons.—At certain periods of the year lead colic is very prevalent, and at others very rare. This difference must be in part attributed to the greater or less amount of work done at certain seasons, and consequently, in the number of workmen employed. Thus manufacturers of white lead are sometimes unemployed for months in winter, and a large proportion of house painters cease work in very cold weather.

Of the twelve hundred and seventeen cases submitted to Tanquerel's observation, at different periods of the year, there occurred in

January,	67	July,	190
February,	77	August,	127
March,	95	September,	92
April,	99	October,	81
May,	115	November,	78
June,	137	December,	59

Total, 1217

This table shows that the greatest number of cases of colic occurred in June, July, and August, the warmest months of the year. From frequent visits to the manufactories of white lead

and minium, and also to other different lead work shops, Tanquerel is certain, that, other circumstances being equal, the number of sick laborers was greater during the warm than the cold seasons of the year. Taking into account the difference in the activity of the work, and in the number of workmen employed, it must be concluded, that heat predisposes to attacks of lead colic, either by favoring the dissemination of lead, or by rendering more permeable the different organs by which lead enters the system.

There are some persons who are attacked with lead colic every year at nearly the same time, although they are employed in the same work from the beginning of the year to the time when they are taken sick. Summer is generally the season for these nearly periodical attacks.

Climate.—To determine positively, whether climate influences the development of lead colic, it would be necessary to visit, or to obtain numerous and precise accounts from physicians who reside in different countries. Deprived of such information, nothing positive can be stated. From analogy, it would be inferred, that there are a greater number of cases of lead colic in warm than in cold and temperate regions. Physicians in several different countries have said that lead colic is not modified in its physiognomy by difference of climate, but has the same symptomatic expression in all parts of the globe.

Age.—Laborers in manufactories of white lead and minium, and house painters, who form the majority of the patients, are in general from thirty to forty years of age, because vigorous men are necessary for these occupations, and persons of this age are more numerous than others; from this it might be concluded, that this period of life predisposes to attacks from lead colic. But this consideration would prevent entire confidence being placed in the following table, as proving that such or such an age predisposes to the development of colic.

AGES OF THE 1217 PATIENTS.

From 5 to 10 years, 8	From 40 to 50 years, 277
" 10 to 20 " 80	" 50 to 60 " 118
" 20 to 30 " 244	" 60 to 70 " 39
" 30 to 40 " 445	" 70 to 80 " 6
	<hr/>
	Total, 1217

Children are rarely employed in establishments where preparations of lead are used, but it is certain that they are very easily affected with lead colic. In a manufactory of fancy cards and paper in Paris, the five or six children employed there are often attacked with this disease, the adults less frequently. Children have often had to be removed immediately, because they were so frequently ill. Many master house painters have been obliged to give up taking children as apprentices, because they were so often attacked with colic; later in life these same persons have resumed these occupations, and lead disease is seldom or never developed. Very young children being rarely placed in situations which favor the development of lead colic, it cannot be known with certainty whether they are predisposed to it or not.

Baron, physician at the "Hospital for newly born Infants," has never observed lead colic in children at the breast. Chaussier, (*Encyclopédie, chim.* tom. 3,) says that white lead in the powder applied to the excoriations and chafings of infants, has produced lead colic. Constipation, hardness, and depression of the stomach, vomiting, dysury, crying, great agitation, and refusal of the breast, in consequence of the use of white lead, without doubt, indicated lead colic in these little beings. But it must be confessed, that here the diagnostic is involved in great difficulty.

Sometimes old men ceasing work, and who had no longer been attacked with colic in their advanced age, yet, on being again in contact with lead, as formerly, were taken ill. In the white lead manufactory at Courbevoie, there were two old men, one of whom had worked eighteen months, the other two years, without being attacked with colic, whilst adults could not work there more than one or two months without suffering from this disease.

The preceding are very general facts, which particular observations will doubtless modify. It would seem from the above remarks, that men are much more predisposed to attacks from colic at the periods between childhood and old age. The only fact that can be established with certainty, is, that the greater part of the patients attacked with lead colic are adults.

Sex. — Women, from the nature of their usual occupations, being but little exposed to contact with lead emanations which produce colic, must of course be much less frequently attacked with this disease, than men. Out of the twelve hundred and seventeen patients only fifty-seven were women. They were burnishers of printers' types, wives of painters, or employed in

white lead manufactories. Generally women, in the same circumstances, are less frequently attacked with colic than men. Is this because they more willingly make use of preservative means than the last; or from the nature of their organization? Some practitioners have asserted, that the reason why women employed in the same establishments as men are less frequently attacked, is, because the work they there perform is less fatiguing and dangerous than that of men. In the white lead manufactory at Courbevoie, women are employed in the same operations as men, and yet are less frequently attacked with colic than the latter.

Constitution.—Individuals who are attacked with colic, are of all constitutions and temperaments. Yet as most of the occupations where lead is worked in large quantities demand vigorous men, it is not surprising that frequently the patients have very strong constitutions.

Out of the twelve hundred and seventeen patients, five hundred and eighty-four were of middling, four hundred and twenty-four of strong, two hundred and eight of feeble constitutions.

Temperament.—The sanguine, nervous, and lymphatic are about equally susceptible to the attacks of lead.

Cleanliness.—Want of cleanliness has been mentioned, as contributing to the development of colic. Lead workers, not careful to wash their hands often, especially before eating, to cleanse their skin from the particles of lead with which it is covered, may be attacked with colic, because they swallow with their food lead which comes from their hands.

Diet.—It is generally thought that bad food and irregularities in diet, such as excesses in food or drink, predispose the workmen to attacks of lead colic. The result of Tanquerel's researches in this respect shows that the greater part of manufacturers, masters of workshops, and laborers, think that excessive drinking powerfully predisposes persons to attacks from this disease. The majority of white lead workers and house painters, in Paris at least, lead very irregular lives, and rarely pass a week without being often more or less intoxicated. Yet among the workmen, even habitual drunkards have resisted colic for years, and even all their lives, indeed have never been sick. But these cases are very rare; usually these men are easily and quickly attacked with colic.

Sometimes the disease does not attack individuals of regular

lives, or if they do suffer, it is only after a long time, and the attacks are renewed at very long intervals. There are sometimes exceptions to this; cases are not rare where persons of regular and sober lives, have at times only worked a few days or months, when they were attacked with colic.

In a number of cases the disease was developed the next day, and even the second day after a debauch. As Monday is the day when the workmen in Paris are most frequently guilty of excess in drink, so a greater number of patients are admitted into the wards of the "Charity" on Tuesday and Wednesday.

Whether fasting influences the attacks of colic, is uncertain, as no direct observation has yet been made of its effects.

Effect of previous Diseases.—It has been remarked that different diseases with which workmen have been previously affected, have had some influence on the ulterior development of lead colic. It might be thought, that individuals habitually costive are more frequently affected with lead colic. It is not so. Persons affected with different diseases of the digestive passages, and urinary organs, among lead workers, are neither more nor less often attacked with lead colic, than their comrades, whose organs are in a healthy state.

Lead Diseases.—Other lead diseases predispose to colic, for lead must be in the system where one form of lead disease appears, consequently, it may at any moment direct itself to the digestive organs and cause colic. Colic much more frequently follows arthralgia than lead paralysis, or encephalopathy.

Recidivation.—Colic often exhibits recidivation. Persons after being cured, on exposing themselves to contact with lead, are again attacked with this disease. Between the recidivation there exists a variable interval, during which, the patient has been exposed to lead.

Thus a first attack of colic, far from protecting the subject from a second, as in many other diseases, disposes them, on the contrary, to be attacked many times. The recidivation becomes more frequent, as the patient experiences a great number of attacks. It has been observed that individuals who have worked for eight, twelve, or twenty-five years, without suffering from this disease, if they are attacked once, then every five or six months they suffer from an attack, and many have been obliged to abandon their situations.

One of the most powerful reasons for this recidivation is,

because the patient, when partially restored, leaves the hospital to work or live in the workshops, surrounded by lead emanations. Does the feebleness of the patient, in consequence of severe suffering, energetic treatment, and diet, favor the absorption of lead, and does the system no longer oppose the manifestation of the presence of lead?

Tanquerel does not confirm the usual belief that recidivations depend on the treatment. Recidivation occurs more or less often, in each individual; some workmen have colic only once in their lives, whilst others are attacked every year or month. Tanquerel has seen patients with their sixth or seventh attack; one patient had been attacked thirty-one times. Desbois de Rochefort, Doasan, Stoll, and Merat, have seen persons attacked with colic, sixteen, seventeen, twenty-two, twenty-six, twenty-eight, and thirty-two times. Of the twelve hundred and seventeen cases observed by Tanquerel, nine hundred and eighty-four had been attacked with colic before the time he saw them.

Relapses. — Patients apparently perfectly cured, without exposure anew to lead, are often again attacked with colic; this is called a relapse. The expressions recidivation and relapse, must not be confounded. Their proper meaning must be maintained, so as not to confound two morbid acts altogether different. The time separating the apparent cure from the relapse, is generally one, or many days, sometimes several years. In all the patients who have suffered relapse of colic, there could be perceived one or more of the *primary effects*, which characterize the presence of lead in the system. How does it operate to produce this mysterious morbid manifestation? Where is the lead during health? What is the cause of its renewed action? Has part of the lead been evacuated by the treatment, whilst the remainder, driven from the parts where the disease existed, circulates again with the mass of the liquids, until, by some unknown cause, it is again fixed on the organs of the abdomen, causing there the original disease?

Tanquerel thinks that relapses take place in nearly one twentieth of the patients. They are generally produced by irregularities of diet and treatment. Individuals who, the day or next day of their cure, take abundant food, are liable to relapse. Food should be taken gradually, and increased daily by degrees. It may not be doubted that if the vomipurgative treatment is omitted, relapses ordinarily ensue. There are very

rare cases of colic, treated with energy, and for a sufficiently long time, which are followed by relapse. (See *Treatment*.) To what can this be attributed? Is it to the influence of temperament, constitution, the quantity of lead absorbed, the number of relapses, that is, of preceding attacks, &c.?

Tanquerel could not elucidate this point by his observations. The characteristic traits of this idiosyncrasy, which facilitate the reappearance of colic, have escaped observation in the small number of cases that have been noticed.

Stoll pretends that a purgative or vomit given at an improper time, easily and quickly causes relapses. Tanquerel has seen nothing of the kind; on the contrary, this treatment prevents renewed attacks.

It is seldom that an individual experiences more than one relapse. An old house painter, for seven years, experienced a relapse every year. This man during the time was not in contact with lead; he had changed his occupation and become a machinist at the opera.

Epidemic lead colics have been mentioned. This name is only given to those which prevail in an epidemic manner, in localities where lead is worked in large quantities, as in lead mines, manufactories of white lead, minium, &c. The name of epidemics has also been applied to those which are produced by the use of wines adulterated with litharge.

Lead Colic in Animals.

Animals exposed to a lead atmosphere or emanations, are liable, like men, to be attacked with lead colic; and Tanquerel has seen cats, fowls, horses and dogs, attacked with this malady. It is chiefly in white and red lead works, and other large establishments connected with lead preparations, in which the animals work and live, that these accidents occur. The animals are particularly liable to be attacked, when day after day they raise clouds of lead dust, by pawing the piles of white lead, or lie down on, or roll over them. The lead dust seems to have entered by respiration, as the skin presents an almost absolute obstacle to absorption. It has also been observed, that cats caged in these places are affected with colic, and all the animals suffer from its attacks when the water which they drink holds lead particles in suspension.

The first authors who noticed these lead disorders among the lower animals, were Burserius and Stockhausen. Wilson and Stokes observed these effects on ~~animals~~ animals pastured in the neighborhood of lead mines in Scotland: cows, horses, sheep, &c. in good case, turned to graze in such pastures, especially if they have been washed by streams from the mines, which leave a slight deposit of lead salts, are infallibly attacked with lead colic. In short, the fact that animals working or living in lead establishments, are attacked with colic, is one of common observation among all physicians who have given their attention to this subject.*

CHAPTER V.

PRECURSORS.

THE characteristic phenomena of the primary effects often precede or announce more or less, lead colic. Of the twelve hundred and seventeen patients, eleven hundred and eighty-five presented, before the appearance of colic, one or more of the primary effects of lead. The presence of the primary effects may then be considered as the true precursor of colic.

All the marks of the primary effects, and colic, are generally manifested in the men whose occupations expose them to contact with a great quantity of lead emanations; hence *all* the signs of primary effects united may be considered as precursors of the majority of cases of colic. When all the marks of the primary effects appear in the same person, lead colic will generally follow.

Very often, jaundice and a sugary taste appear only one or a few days before the development of colic. When the directors of the great lead establishments perceive one of their workmen suddenly acquire an earthy yellow color, they oblige him immediately to leave his work, persuaded by their daily experience that he will soon be attacked with colic. The workmen themselves, when they experience, for the first time, a sugary, styptic

* The ill effects of pasture near lead mines and founderies has been also observed in Derbyshire, England. — S. L. D.

taste, or if this sensation previously existing, becomes more decided, fear an approaching attack of colic.

Lead colic is generally preceded by morbid phenomena in the stomach, the commencement of the symptoms which afterwards reveal the entire development of the disease. Workmen threatened with colic, at first feel a weight in the epigastrium, dull and fugitive colic pains in the pit of the stomach, which increase especially after eating, sometimes also nausea appears, as well as borborygmi and eructations, the appetite diminishes and finally disappears, the bowels, previously free, insensibly lose all power of evacuation, the excrements assume a globular form, and often become harder, and of a blackish or yellowish color, the urine also is expelled with some difficulty, and even with a slight feeling of pain.

Workmen remain for several days, sometimes even for weeks or months, tormented with this slight abdominal pain, without leaving their work. This happens especially when these precursors seize them at intervals of hours, days, or even weeks.

At last the pains suddenly and briskly acquire more intensity, and return at shorter intervals; then new symptoms appear. The workman, wearied with cruel and continued suffering, can work no longer; the disease is completely manifested. In some rare cases the precursors constantly increase in intensity, and by successive degrees, until colic is perfectly developed. Sometimes an excess of alcoholic drinks, of food, or work, hastens the precursors, and contributes to the complete and rapid development of the disease. As for the rest, no connection can be established between the intensity of the colic, and the longer or shorter duration of these precursors.

Colic rarely attains immediately its greatest height, yet this does happen in some cases, (about three out of a hundred,) especially if it is a relapse. The moment before the patient perceived no derangement in his digestive or urinary organs, suddenly the symptoms of colic are manifested with violence, and oblige him to leave his work.

Sometimes diarrhœa following soon after constipation may announce the approach of colic. Tanquerel has observed this precursory sign eighteen times. In all these cases the diarrhœa had lasted from one to eight days; immediately on the appearance of colic it ceased, and was not renewed. Several patients

having this precursor of diarrhœa, had passed the night before the appearance of this disease in drunkenness.

In certain cases before the manifestation of colic, the workman, previously gay, becomes morose, his features seemed *weighed down* rather than shrunk up. All exercise is fatiguing, sleep is fleeting and unrefreshing. Two of the patients observed by Tanquerel complained of feeling unusually cold and shivering for some days before the attack of colic. It very often happens that lead arthralgy, (neuralgic pains in the limbs,) precedes colic; Tanquerel saw this form of lead disease as a precursor of colic one hundred and ninety-five times. He has three times seen paralysis of the upper limbs, and once, amaurosis precede colic. Anæsthesy of the limbs and body was a precursor of colic in two of the patients.

In two cases lead encephalopathy appeared before the manifestation of diseases in the stomach. In nearly one third of the patients the disease began in the night, breaking their sleep. In a certain number of cases the precursors did not manifest themselves in the night, but the colic was completely developed at that time.

The patient is liable to be attacked with this disease in all situations, at his business, when eating, drinking, or sleeping, &c., &c.

CHAPTER VI.

SYMPTOMS.

THE morbid phenomena which reveal the presence of lead are numerous. The digestive, urinary, and circulatory organs are the seat of functional changes characteristic of this disease.

Pain.—The most important symptom that characterizes lead colic is pain. Its seat is habitually about the umbilicus, less often in the epigastrium or hypogastrium, more rarely in the renal region, the hypochondria, the sides, the iliac fossæ, the anus, the testicles and their cords, the thorax.

Of the twelve hundred and seventeen cases observed by Tanquerel, with reference to the seat of the pain, in two hundred

and two cases the disease was exclusively in the umbilical region, in one hundred and sixty-seven cases it was limited to the epigastrium, in one hundred and forty-nine cases it had attacked the hypogastrium only, in twenty cases the renal region alone was attacked, twelve patients complained exclusively of colic pains, either in the hypochondria, sides, or the iliac fossæ.

In five hundred and seventy-three individuals affected with colic, the pain occupied at the same time several parts of the abdominal cavity in different degrees, but always with the same relative frequency. Thus the umbilicus, epigastrium, hypogastrium, &c. were more frequently painful simultaneously.

In ninety-two cases only the pain extended through the whole abdomen, in forty-five of the preceding patients the testicles, spermatic cord, and the penis, were painful.

Finally, in nineteen cases the abdominal pain had extended to the thorax. Tanquerel has never seen colic pain follow completely and exactly the course of the colon.

In cases of simultaneous pain in several parts, there is almost always one part which the patient complains of more particularly, and the seat of which varies according to the observations of Tanquerel, in the following manner —

Umbilicus, commonly the most painful region,	243 times,
Epigastrium,	184 “
Hypogastrium,	150 “
All other parts of the abdomen, the renal region, testicles, &c.	90 “

It is sometimes difficult to limit the pain to such or such a place when it occupies the bounds of two contiguous regions. In some cases it forms a perfect circle around the abdomen and corresponding part of the body.

It very often happens that the pain seizes only one portion of the regions just assigned, as its seat. Thus the seat of the colic pain generally corresponds to the abdominal median line, the navel, epigastrium or hypogastrium. Even when the pain occupies the whole region of the abdomen the most painful points are generally those just named, which are as a centre, a point of departure whence the flashes of pain radiate.

This colic pain generally consists in a violent twisting sensation. In other cases less numerous it is an acute feeling of dilaceration, tearing out, pricking, burning, boring. Sometimes this increase of sensibility is compared by the patient to a simple

constriction, or rather compression, produced by a weight upon the abdomen. In this last case the abdominal pains are generally obtuse, and their progress continues to be nearly uniform. In all other cases the pain is so intense that it throws the patient into the greatest agitation, but then it is not always the same; it becomes more severe by fits, either by day or night.

If the attack of colic is very severe, the patient is a victim to the greatest anguish, the whole countenance is disturbed, the eyes hollow, dull and wandering, and the unfortunate sufferer utters the most rending cries, frightful groans, and sometimes a sort of bellow, as mentioned by Stoll. At the same time the tormented subject is constantly restless, every moment changing the situation for the purpose of allaying the violence of the pain, and with the hope of finding some relief from a new position. Some lie flat on the stomach, alternately taking and leaving a horizontal position. Others throw themselves crosswise on the bed, rise up suddenly to walk, holding their hands upon the bowels, but the violence of the pain soon compels them to discontinue their walk. Some roll upon their bed or even on the floor, double themselves up, wind themselves all in a heap on the anterior part of the body, and take a thousand other odd positions. Many cling to some point of support by their hands, and keep a constant balancing motion. It is not uncommon to see persons whose whole body is agitated with jerking or trembling motions, like those of violent shivering in intermittent fever, conceal themselves far down, and gather themselves up under the bed clothes. Some of these sufferers strike themselves on the abdomen, body and limbs, bite their fingers, &c., &c. Nearly all place their hands upon the stomach and bowels and rub them, or vigorously apply their fists to the umbilicus, hypogastrium or epigastrium. They have been seen to place coverlets, pillows, mattresses, chairs, &c., on the abdomen; there are some who compress themselves by means of cravats, cords, &c. Finally, Tanquerel, like some other writers, (Fernel, Merat,) has seen some patients get their comrades to mount upon their stomachs. All these positions, which vary infinitely, may be taken alternately by the same patient, in the course of several attacks of colic.

Sometimes the sufferings of these unfortunate beings, so completely overpower them, that they perceive nothing that passes around them. They often reply incompletely and sometimes not

at all, to questions that are addressed to them. The acuteness of the pain is sometimes so great, that they do not feel hot water or burning substances applied to the stomach. One patient was so exasperated by the acuteness of the pain, that he wished to cut his throat with a razor, or throw himself out of the window.

In the course of some seconds, minutes, and even in some cases, whole hours, this formidable array of pain disappears or at least diminishes in a perceptible degree. During the abatement, the cries are hushed, the contortions stopped, a calm ensues, the countenance is partially composed, the patient is immovable, fatigued, broken down, as if annihilated; he scarcely complains, and yet still feels in the abdomen either a constriction or grievous compression, a kind of pinching, or else a less degree of the violent sensation of twisting experienced during the attack. In some very rare cases no pain is felt during the remission.

But the moment of calm, of relief, soon gives place to a new attack of colic, to which succeeds another period of relief, and so on. The intervals of relief vary from a few seconds, to hours and even whole days. In general, where the pain is most violent, the attacks are more marked and connected. To this rule there are some exceptions.

The attacks of colic which follow each other are not separated by perfectly equal intervals. They often vary in violence. It sometimes happens that in two attacks succeeding each other, the most painful point in one case is not so in the other, so that the appearance of each differs a little. The violence of the exacerbations varies considerably from one day to another without apparent cause; the seat of the severest pain is not always the same.

In proportion as colic progresses, the paroxysms are more defined; when, on the contrary, it is nearly over, the pain is almost constant. The attacks return without any assignable cause; they often appear to be more frequent and more violent by night than by day. The day scarcely dawns before the suffering in a great measure disappears, as if by enchantment. The contrary effect scarcely ever occurs. Except these circumstances, no cause can be assigned for the return of the attacks. This formidable colic pain comes suddenly in a few hours, in the most opposite and various circumstances. Some patients imagine that speaking, coughing, breathing fully, drinking, moving, &c., are so many causes producing the return of attacks of colic.

In a very small number of cases, the pain, though violent, was constant, that is, it was as severe at one time of day as another. Yet even in these circumstances, the patient seemed at some moments to suffer a little less than at others, though he said the contrary.

Colic is called violent or light, according as the pain is more or less acute. The degree of the disease is measured by the intensity of the suffering. Thus the force of colic varies in an infinite degree. Of the twelve hundred and seventeen cases of colic, four hundred and seventy were violent, four hundred and eighty-five moderate, and two hundred and sixty-two light.

When the colic pain is moderate, the patient is still agitated. But this agitation does not resemble that of violent colic. At the moment of attack the patient utters groans or complaints, tosses and turns in his bed, lies upon his stomach, side, &c., without doing any thing extravagant.

In cases of light colic, the patient often lies quiet in his bed; at the moment of attack, which in some is so well marked, he scarcely moves, rarely changes his position. His body, which is a little shrunk up, is the only indication to the eye of the observer of the existence of suffering.

It is characteristic of the pain not to be increased by pressure; it is very often diminished on pressing the abdomen. The different manœuvres that the patient instinctively makes upon the stomach and bowels at the moment of attack, show that pressure on the abdomen often eases the pain. But to obtain this result, that is relief, some care is necessary in the mode of exploration. In general, when the influence of pressure on pain in the abdomen is to be examined, it is necessary to vary infinitely the mode of application; for a great number of patients experience different effects, according as it is exercised in this or that manner, or on such or such a part of the abdominal cavity. Thus, when pressure is made suddenly, and with force on a limited point, it generally aggravates the suffering, while if extended over a large surface, with the whole palm of the hand spread out, at first gently, then with force gradually increasing, the pain is often perceptibly diminished, or at least not increased in acuteness. Yet in some cases, pressure with the fist diminishes the pain, whilst that with the palm of the hand increases it. It is important to charge the patient not to contract the abdominal muscles during this examination. It has several times happened,

that by previously bending the lower limbs on the pelvis, relief has then been given by pressure, which could not be obtained while the muscles of the abdominal parietes were contracted. Some patients are relieved by strong pressure, whilst a light one only aggravates their suffering. On the contrary, simple rubbing often diminishes the pain, whilst strong and energetic pressure increases its acuteness.

In some cases where pressure increases the pain, it is not in a very marked manner; there is only a slight increase of colic. Even in these latter cases, the patients at the moment of attack generally lie on the stomach, which they press with their hands and their fists, which proves that the pain is not greatly increased by these motions.

In a very few cases of simple, downright, and legitimate colic, the pain was excessively increased by the least pressure, and to such a degree, that it might have been thought these were cases of acute peritonitis. But all the other symptoms of abdominal lead disease exist, and then, notwithstanding this pain is so violent on pressure, yet the patient lies sometimes on the stomach or side, at the moment of exacerbations; from one minute to another, from day to day, it also increases or diminishes in intensity by pressure.

Tanquerel has never remarked, as have some writers, that the abdomen was always sensible to pressure at the moment of attack. On the contrary, he has generally observed that relief was more decided at the moment of the exacerbations, than during the paroxysms. Sometimes, he has even seen the pain diminished by pressure at the time of the exacerbations, and increase a little during the remission. But he has never observed the opposite.

In certain cases pressure on the abdomen changes the seat of the pain, either causing it to ascend to the epigastrium, or descend to the hypogastrium; then it does not change its intensity, or else increases or diminishes it.

The influence of pressure on the pain is not always the same. Thus, in cases of colic where the pain is felt in several regions of the abdominal cavity, compression increases the pain in one part, and relieves it in a more or less marked degree in another. In general, where the pain is the sharpest, there the influence of pressure is most felt, by the diminution or increase of suffering.

It sometimes happens that the influence of pressure on the

patient is modified from one day to another; to-day it gives relief, to-morrow it does not change the acuteness of the pain, or even increases it. The result of pressure does not vary with the intensity of the pain. Yet in two cases of colic, one light, the other violent, diminished or increased by pressure, the effect of this last operation was most apparent in the case of violent colic. Colics which are increased by the application of the hand are not more serious or more intense than others.

Why this difference in the influence of compression? Is it from constitution, idiosyncrasy, manner of feeling, &c.? It might be thought so, for in several attacks of colic in the same individual, pressure always produced the same result.

Complications of inflammatory or other diseases in the abdominal organs, cause the effects of pressure to vary. Of the twelve hundred and seventeen cases of lead colic, seven hundred and three were relieved by pressure. In three hundred and three, pressure neither increased nor allayed the pain; in one hundred and seventy-five cases, the suffering was slightly increased by pressure, in thirty-nine cases, the increase of pain was considerable; but in thirty-four of these patients there was a complication which accounted for this result. Thus in about two thirds of those attacked with colic, the pain was diminished by pressure, in nearly one fourth there was a diminution or increase of suffering; about one sixth experienced a little more pain, and some felt much more severe suffering from pressure.

Constipation. — Constipation is, next to pain, the most frequent phenomenon which characterizes colic. This symptom, like pain, manifests different degrees. In cases of violent colic, when the disease has reached its greatest intensity, constipation is so severe that drastic purgatives, administered by the mouth, are necessary to overcome it, for it is not removed by simple purgative injections. Constipation is much more rare in very light colic; there is then only a difficulty in alvine evacuation.

The patients sometimes continually feel that they are going to reject excrements, but after considerable efforts, all is useless, nothing is evacuated. This deceitful sensation fatigues the patient extremely, some are even attacked with piles after these efforts, which disappear only after every thing has returned to its natural order. This disease often occurs, according to the report of Wilson, in workmen in the lead mines at Lead Hills, when they are attacked with lead colic.

The stools generally fail for several days; in one case observed by Tanquerel, there had been a suppression for two weeks. Sometimes, instead of constipation, there is diarrhœa. Of the twelve hundred and seventeen patients, eleven hundred and forty had been attacked with constipation, thirty-three enjoyed natural evacuation, twenty had diarrhœa during the two first days, and nineteen during the whole period of the disease. Diarrhœa occurs without disease complicated with lead colic; in thirty-one cases only, the usual characteristic symptoms, concomitant with this form of lead disease, appeared; purgative treatment, generally, promptly and completely removed the diarrhœa, as well as all the other functional alterations. In these cases where diarrhœa existed without complication, the pains were very severe.

Generally, the intensity of constipation is in proportion to the violence of the pain. Yet Tanquerel has never seen a case of lead colic free from complication, which was more violent than that with which a painter was affected every year, and of which he was cured each time at the "Charity," by drastic purgatives. In this person lead colic was always accompanied by diarrhœa.

In December, 1837, a slight epidemic diarrhœa prevailed in Paris. Several persons (six) who were attacked with lead colic during this time had diarrhœa, without any other complication not due to lead. The epidemic had impressed its own characteristic phenomena on colic. The ordinary treatment easily dissipated the diarrhœic lead colic.

When in consequence of the treatment or by the unaided efforts of nature, the patients go to stool, evacuation is effected with the greatest difficulty, sometimes amid uncommon efforts. Divided into small rounded portions, the first matters that the patients evacuate are generally dry, hard, yellow or black, like the dung of goats (scybala). Received into a night vessel they swim on the top of a small quantity of liquid that has been evacuated at the same time. They often only become liquid after the administration of drastic purgatives, or when a cessation of pain has been obtained by other treatment.

Yet sometimes, especially when colic lasts a long time, the stools, at first obtained in small number by the aid of purgatives, consist only of a more or less thick mucous liquid. It is only later, by frequently repeated drastic purgatives, that these hardened matters can be dislodged, which then appear in considerable

quantities after numerous efforts. This result should encourage the physician to continue the use of energetic purgative medicines, though at first the stools may not appear to indicate constipation.

Each stool does not produce much alvine matter. Eighteen stools only gave about six pounds of excrements according to Merat. Luzuriaga has remarked, that they blacken silver, but chemical analysis shows why all stools have this property.

Retraction and hardness, or depression of the abdomen, are frequently observed in the course of lead colic.

Of the twelve hundred and seventeen patients, in six hundred and forty-nine, the abdomen was retracted, in four hundred and forty-five it was neither full nor depressed; and in one hundred and twenty-three it was larger, more developed, more projecting than usual, but in none of the cases was it inflated. These numerical results certainly conform to those that daily experience teaches, for without these additional facts the general impression nearly coincides with this proportion. Tanquerel has not been able, from the facts that he has collected, to establish any regular proportion between the intensity of the pain and the retraction of the bowels; though this is the opinion of Merat. Depression of the abdomen is much more decided in chronic than in acute colic. It is rarely absent from the first.

Retraction of the abdomen may be manifested in infinite degrees. Sometimes it is so much depressed that it seems as if glued upon the spine, which then can be felt by the touch. Sometimes the abdominal parietes appear only a little less projecting than in the normal state. The abdomen may be uniformly and considerably depressed. In other cases, on the contrary, this depression is more decided in one point than in another; very often it is about the umbilicus, which seems sunk as in a cup, or else the epigastrium and hypogastrium are particularly the seat of retraction. If the abdominal parietes thus depressed are examined by the hand, they will be found tense, and sometimes as hard as stone, giving the same sensation to the touch as the muscles in the calf of the leg when affected with cramp. This hardness and tension of the abdomen could not be overcome by bending the lower limbs on the pelvis, or by diverting the attention of the patient from it. The intestines appear to form a part of these energetically contracted muscular masses, although this can be always positively determined by

pressure. In violent attacks of pain, the hand applied on the abdomen seems sometimes to be repulsed by the sudden and energetic movements by which it is agitated. Cases have occurred where the abdomen was visibly agitated in every way by sudden, precipitate motions, like convulsions, especially at the moment of the attack of pain. Contraction may be general or partial.

Tumors or bunches, varying in size and tension, are produced by the unequal and partial hardness, and may be distinguished through the parietes of the abdomen.

Depression, and especially contraction of the abdomen, appear more marked at the moment of the attack of colic. In the interval of the paroxysms, it is less depressed and more supple. This observation, that Tanquerel has often verified, and which is disputed by Grisolle, explains the sudden disappearance, noticed with so much care by ancient writers, of these pretended *unequal, movable tumors*, which can be felt through the parietes of the abdomen. "In one patient," says Andral, (*Clinique Médicale*,) "a very hard tumor, seemingly formed by agglomerated intestinal convolutions, appeared in one part of the abdomen; this tumor lasted as long as the pain, disappeared with it, and the abdomen again became supple and insensible." Tanquerel has several times observed such tumors that might be called remittent, they projected so much that they could be perceived even without touching them.

Sometimes, as will be seen hereafter, these tumors formed by the partial contraction of the abdomen, contain a certain quantity of gas, then they move and change their places. Tanquerel has never seen the stomach shrivelled in consequence of pain, as is stated by Stoll.

Depression and contraction are in general more decided when extending over the whole, than when limited to a particular region of the abdomen. Tanquerel has seen but one hundred and thirty-five cases of lead colic, where the bowels and the abdominal parietes were supple, and rounded as they should be in the normal state. In all other cases he noticed tension, hardness, inequality, a more or less energetic contraction of the abdomen. The retraction of the abdomen appeared most often to be in proportion to the degree of tension and hardness of the visceral cavity. Yet in a large number of cases of contraction, there was no sensible depression. The *embonpoint* of the ab-

dominal parietes, the accumulation of gas in the intestines, are obstacles to the apparent retreat of the abdomen. Therefore the hardness or spasmodic contraction of the abdomen is a much more general phenomenon than its depression.

In general, where the colic pain is most acute, the hardness and contraction are more decided. There are some exceptions to this rule, the cause of which it is difficult to discover. The retraction and hardness of the abdomen is proportionate to the pain, hence, where one of these phenomena is more marked, the others are also greater.

Compression of the parietes of the abdomen does not produce sensations corresponding to the retraction and hardness. Therefore, pressure does not give any more relief when the abdomen is depressed, than when it is supple, when it is swollen, than when it has preserved its natural size.

Painful tenesmus is sometimes felt. The anus often appears sunken, contracted inward, especially at the moment of violent attacks of colic; it seems to some patients as if it was tightly corded. Several writers have endeavored to prove that in lead colic the intestinal tube has a sort of convulsion, or spasmodic contraction. To prove the reality of this opinion, some have stated that the rectum was convulsively contracted. If it was certain that the rectum was affected with a convulsive obstruction, it might be affirmed, with some reason, that the upper part of the intestinal tube was so, where the pain is principally seated. Tanquerel has examined the rectum in a great number of persons affected with lead colic, and to avoid all error, the examination was in each case made in patients who had no disease of the digestive organs.

In a case of violent colic, if it is attempted to introduce the indicator into the rectum, very great difficulty is experienced at first in making it penetrate the sphincter, which is so vigorously contracted, that the finger experiences a sensation of oppression and numbness, as if it was held in a vice. Finally, by pushing with some energy, the resisting force of the anus may be overcome, and the lower part of the rectum reached, the parietes of which will be found drawn near to each other. For some lines, and even an inch beyond, it will still be observed that the opposite sides of the intestine nearly touch, and it is then necessary to separate them mechanically with the finger to penetrate any farther. If the finger is kept thus during several attacks of

colic, at the moment of each attack, through the whole extent of the rectum in contact with the finger, will be felt the same sensation of pressure and numbness as at the circumference of the anus, but in a less degree. During the remission, this sensation of constriction always remains, although it is much less decided, and returns with more force during the attacks. This alternation of pressure and relaxation, is generally very easily noticed in violent colic, but observed with difficulty in slight attacks.

The contraction of the anus and rectum restrains without completely preventing the administration of injections, only more than usual force is required for this operation in patients with lead colic; such is the experience of nurses. The injections are also more quickly returned. The introduction of the finger into the rectum usually relieves the patient, increases the desire of evacuation, and the excretion of gas.

Tanquerel is satisfied, that the anus and rectum of persons attacked with colic, are affected with a spasmodic contraction analogous to *cramp*.

Some modern observers, of great merit, have raised a suspicion of the existence of a morbid contraction of the muscles of the anal region and the rectum, and consequently a diminution of the calibre of those organs in lead colic. Tanquerel thinks this assertion is probably made, because they had not examined the rectum in a large number of persons attacked with lead colic, and because they had not kept the finger long enough in that position to experience that alternation of pressure and relaxation which takes place during the attack and remission of colic.

Nausea and Vomiting.—Nausea appears much oftener than vomiting, which it usually precedes; it was noticed in nine hundred and eight patients. In some cases, pressure on the abdomen from below, and upwards from the hypogastrium towards the epigastrium, at the same time that it relieves the pain produces nausea. Vomiting very frequently exists; four hundred and twelve, of the twelve hundred and seventeen patients, were attacked with it. The duration, frequency, and abundance of the vomiting are not always in proportion to the acuteness of the pain and the other symptoms. This accident seems particularly to accompany colic seated about the epigastrium. Three hundred and eighty-five of the patients who were attacked with

vomiting had more or less violent pain in the epigastrium; eighty-eight, only, vomited without feeling any decided suffering in the stomach, but in these, vomiting was generally neither very obstinate nor very abundant. Tanquerel has seen but a very small number of cases of epigastric colic, that were not accompanied with vomiting; in these, the pain in the epigastrium was slight or moderate.

Vomiting is often performed with the greatest difficulty. In many cases it is only after uncommon efforts, followed or accompanied by a feeling of pain, and even great distress, that the patient finally throws up the matter contained in the stomach. The unfortunate sufferer is frequently seen placing his fingers in his mouth to assist this evacuation, from which he hopes to obtain relief, which sometimes comes, but not very often. The matter vomited sometimes leaves in the passages a painful feeling, and the tongue is colored with it.

Vomiting is generally repeated at short intervals; sometimes at the moment of the attack of colic, sometimes during the remission, which is most commonly the case. Each time a small quantity is thrown up. In a few cases, slight pressure, or the least motion brought back vomiting. There were some patients, in whom even the act of spitting produced vomiting.

Sometimes liquids taken into the stomach relieve directly, or cause vomiting, which gives a little relief; sometimes, on the contrary, they increase the sufferings, excite painful vomiting, or produce a feeling of fullness amounting almost to suffocation, especially if administered in a very large quantity at once. There are some patients who vomit dilute ptisans, and who do not reject exciting tonic drinks, and *vice versa*. Finally, most frequently the introduction of any liquid into the stomach effects no modification in vomiting where it exists originally, and does not produce it if it did not exist anteriorly.

Merat thinks that vomiting is usually provoked by the treatment. Tanquerel's observations do not agree with this opinion. Vomiting most frequently exists at the commencement of the disease, as soon as the pains are felt; it generally ceases betimes in one or two days, before treatment has been commenced. In a large number of cases, the patients brought to the hospital, are already free from this symptom, when the first remedies are administered to them, which contribute in other respects to allay, not provoke this evacuation. In a certain number of

cases, vomiting sometimes continued to the decline of the disorder; this was chiefly when the seat of colic was in the epigastrium, and when it was very painful; this continuance of vomiting was an obstacle to the administration of remedies through the mouth.

The matter vomited has a greenish hue, a viscous consistency, a very fetid odor, *sui generis*, an extremely bitter, coppery taste, that some patients say is analogous to lead, others to verdigris, &c., according to the idea that they have of the substance which has produced their colic. In none of the patients did the matter vomited produce in the mouth the same sensations as a sugary substance. This is a symptom that several observers say they have met with, but they have probably confounded it with the sugary taste which some patients perceive when they eruct gas through the mouth, or when they have worked where they breathed or swallowed air loaded with the dust of white lead; but it is not vomiting which produces this sweetish sensation.

Some patients, after having made great efforts to vomit and thrown up a large quantity of bile, at first clear, then very thick, which is deposited in a large quantity at the bottom of the vessel, finally vomit bloody matter, mucus striated with blood.

Gas.—A considerable quantity of gas is very often formed in individuals attacked with lead colic, it generally escapes through the mouth with a noise (eructations). It rarely comes out through the anus, and even in that case, it is excreted in a much smaller quantity than by the superior part of the digestive tube. Tanquerel has noticed borborygmi in three fourths of the patients in different parts of the abdomen, but especially in the right iliac fossa. Merat says, on the contrary, that borborygmi are rare, on account of the almost general contraction of the digestive tube. This proposition evidently is not founded on facts, but on purely theoretical, preconceived ideas.

Gas accumulating in some parts of the digestive tube, forms projections or tumors, that percussion, compression, and their mobility distinguish from tumors formed by spasmodic contractions of the intestines. Sometimes these tumors are formed by spasmodic contractions of the intestines. Sometimes, these tumors are formed simultaneously by gas, and by contracted portions of the abdomen. This gas is often in motion, sometimes, especially during the remission of the pain, it runs through the alimentary canal with astonishing rapidity, accom-

panied by a more or less sensible noise, a kind of gurgling sound. Some patients point out the passage of this gas in the different parts of the abdominal cavity. Sometimes there can be perceived an alternate contraction and dilatation of the intestines and the parietes of the abdomen to give passage to the wind. When the abdomen is distended, it depends partly on the great quantity of gas which it contains; its accumulation rarely produces general inflation. In some cases, compression of the abdomen makes this gas circulate with very great ease and with some noise, occasioning a diminution or increase of the pain.

Some patients experience a painful feeling of distention in the intestines, from this accumulated gas, so that its excretion is often a relief. Frequent eructations are generally very fatiguing. In some cases, from time to time, a painful sensation rises from the epigastrium to the throat, accompanied by an evacuation of gas, sometimes nausea or vomiting succeed or precede it.

This gas often has, like the matter vomited, a bitter, fetid, or specific odor and taste. In several persons attacked with colic who had just left their work, and especially in workmen still engaged in their shops, Tanquerel observed excessively frequent eructations, which, according to the account of these patients, produced in the mouth the same sensation as a sugary substance. This circumstance, very rare, has been previously mentioned by Orfila.

Hiccoughs.—Tanquerel observed hiccoughs one hundred and fifteen times, they always coincided with vomiting, eructations, and the epigastric pain. In general, individuals in whom hiccoughs appear are attacked with an intense colic. They appear with the return of attacks of pain, or in their train, at the same time as nausea and vomiting, which they may also precede. Some patients experience great inconvenience from them, others do not complain of them. The sufferer often belches in the sudden jerkings of hiccoughs, which gives to the whole abdomen and especially the epigastrium, a convulsive agitation.

Tongue.—The tongue is generally moist and dewy on the sides and tip, covered with a light white, and sometimes yellow coat in the middle and at the root. It has very often been found larger than in the normal state.

At the commencement of colic the surface of the tongue is clean, but after some days this whitish coating, slightly thick

and very adhesive, is almost constantly apparent. This result cannot be attributed to the use of drinks, for it appears equally in individuals who drink ptisans.

The tongue in individuals who have been tormented for four months with colic, was always in the state just mentioned.

Where the tongue becomes red, grayish, chapped, dry, and where its papillæ are much enlarged, it is in consequence of an inflammatory complication, or rather, a general disturbance of the circulation in consequence of violent colics, or an attack of delirium, epilepsy, or coma, yet this is not always the case. Some patients have had a red, large and dry tongue without inflammatory complication, or lead encephalopathy; the other morbid phenomena were those of simple, downright, legitimate colic, and the ordinary treatment, by drastic purgatives, succeeded wonderfully in overcoming the disease, and causing this state of the tongue to disappear. To what shall this difference in the state of the tongue be attributed?

These results agree with those of all observers who have paid attention, without preconceived ideas, to the state of the tongue in lead colic. (Merat, Louis, Grisolle, &c.)

Teeth—In colic, may generally be observed that peculiar state of the gums and teeth enumerated among the *primary effects*. Sometimes the patients complain of pains in the teeth like those felt after eating acid fruits; this is principally in patients who suffer acutely. (Palais.) Tanquerel has seen this symptom only twenty-eight times. The patients had no decayed teeth to which they could attribute this pain; they did not suffer in other parts of the face and head. But this phenomenon appeared as often in light as in violent colic.

The breath in the greater part of individuals attacked with lead colic has a very characteristic, specific odor. Very often the *styptic or sugary taste* experienced by workmen before being attacked with colic, is replaced by a sensation of extreme bitterness. Sometimes the patient does not experience any disagreeable sensation in the mouth.

Saliva.—In five cases of true, simple, and legitimate colic, observed by Tanquerel, the saliva was acid. He found it impossible to discover the cause of this singular acidity in all the train of the symptoms of this disease. Generally, the saliva was alkaline, as in the healthy state.

Some patients complain of a very decided sensation of dryness

in the mouth, and say that their saliva is sensibly diminished. This diminution in the salivary secretion may be observed in cases of violent or light colic. Other patients say, on the contrary, that saliva is more abundant than in the normal state. Tanquerel has never observed a single case of salivary supersecretion, or salivation, unaccompanied by stomatitis, angina, &c. In 1836, at the Hospital of Charity, there was a white lead worker attacked with very violent lead colic, and a slightly painful salivation. Several persons who visited this patient told Tanquerel with eagerness that this man had lead salivation, a disease that he had not yet met with. On examining this individual, he perceived that a dental fistula, caused by the caries of a molar tooth in the upper jaw, had occasioned an inflammation of the mucous membrane of the mouth, pharynx, and tonsils. This concealed inflammation was the cause of salivation, for from the replies of the patient it was certain that this disease had appeared a month before the attack of colic. After a few days' treatment, this man left perfectly cured of the colic; but the stomatitis and salivation were in nearly the same state as when he entered the hospital.

Thirst is generally very powerful, sometimes it is not found at all, in a few cases it is very violent. These different modifications of thirst seem connected with no particular phenomena; no relation exists between it and the greater or less intensity of the colic. Even in cases where colic lasts for a long time, the desire for drinking is not felt stronger than at the commencement of the lead disease. It is not very uncommon to see the person relieved, when thirst is assuaged by drinking; there are other patients, who, tormented by thirst, dare not drink, because they experience a feeling of suffocation, stifling, as soon as they have swallowed any liquid.

Appetite. — It is rarely that the appetite is preserved. Yet some patients, in the midst of the most acute pain, ask for food. When their request is granted, the disease is increased, acquiring more energy from the presence of food in the stomach.

Even a small quantity of nourishment, taken too soon into the digestive organs, quickly recalls the colic that was thought to have been completely quieted. Thus, before allowing food, the complete disappearance of the lead disease should be positively ascertained. Want of appetite does not usually accompany disgust for food and drink. The patient does not complain of a

clammy taste in the mouth, except where sugary and gummy drinks have been freely used. In some cases the patient has a feeling of constriction, or of a foreign body in the œsophagus, and sometimes experiences a difficulty in swallowing. Tanquerel saw three male patients, who experienced during the whole course of the colic, the sensation of a ball rising from the epigastrium to the thorax and throat.

Urinary organs and functions usually exhibit the following alterations when colic pain is seated in the hypogastric and renal regions. In some cases, during the paroxysm, there is a sensation of obstruction about the neck of the bladder.

It is difficult to introduce a catheter into the bladder during the access of pain, but it easily enters during the remission. The attempt to perform this when the pain is violent, almost induces convulsions.

A desire to pass water is felt, but notwithstanding the unusual efforts during the paroxysm, it is discharged only by drops. In the remission of pain, urine flows freely, and sometimes after vain efforts spirts out all at once, *pleno rivo*.

If, at the moment of access of vesical pain, the patient passes water, the jet sometimes suddenly stops, a phenomenon noticed by Stoll and Dance, who attributed it to a sudden powerful contraction of the urethra. This opinion seems to be confirmed by the fact, that a sudden and remarkable collapse, retraction, and almost a disappearance of the penis, is simultaneous with the cessation of the flow of urine. During, before, and after micturition, there is felt in the urethra great heat, a smarting and burning.

The rarity and suppression of urinary evacuation may depend on the want of secretion; this is quite probable in colic seated in the renal region.

In this case the access of pain is felt in the anterior part of the abdomen. This pain is diminished by pressure, and shoots along the sides to the bladder; it must not be confounded with that which attacks the loins and which is exasperated by motion, (*lead arthralgy*.) In other cases the bladder is painful, and cannot be wholly evacuated; urine may be discovered in it both by the catheter and by percussion. The distension of the bladder is never like that caused by an accumulation of liquid in paralysis of this organ. The repeated efforts of the patient,

discharging a few drops in each trial, and the usually diminished secretion, prevent an accumulation of urine.

In cases of painful excretion, the urine is redder than natural. It is very rarely colorless. In seven patients it was highly charged with uric acid, but in all the others the urine was in its normal acid state, with the exception of two cases only, where it was alkaline. In these, the alkalinity could be referred only to lead colic, which pain was seated in the hypogastric and renal regions, and accompanied with dysury.

Tanquerel has observed no unusual sediment in the urine, nor does he confirm the statements of other writers who speak of the frequent occurrence of lateritious deposit verging to a green color in the urine of patients with lead colic.

Genital Organs and Functions.—The organs of the male, and the uterus, vagina, and its appendages, are sometimes the seat of colic pains. There are sensations of pulling, tearing, constriction. Pain may attack both testicles at once, rarely one only, though one may be much more painful than the other. When pain is severe, these organs are retracted during the exacerbation.

If the left testicle only is attacked, it becomes retracted and assumes a position nearer the ring than usual, and thus the natural hanging of the left lower than the right testicle, is reversed. The pain is relieved by pressure, and suspension ordinarily relieves the distress. The scrotum becomes wrinkled during the attacks of pain, and again relaxes in the remission.

In two females attacked with lead colic, the pain was seated in the vagina, and about the uterus. It was described by one of these patients, as severe as that of parturition. Tanquerel does not confirm the observations of some earlier writers, that amenorrhœa and sterility were consequent to lead colic; nor has he noticed any general reciprocal influence of lead colic and the catamenia. The last have sometimes suddenly ceased, sometimes have not duly appeared, sometimes deferred their expected return, during lead colic. A very violent attack of this disease was relieved, as if by enchantment, by the un hoped for occurrence of this discharge.

In general the pain in the genitals is little influenced by that of the abdominal organs. It is commonly most severe in the intermissions of pain in other parts. Tanquerel affirms, therefore, that the pain in the genitals does not proceed from the abdominal organs, but there is an attack of colic on two distinct points, simultaneously.

Respiration.—Some patients complain of a feeling of constriction, pressure in the precordial region, or all around the chest. Others feel pains in different parts of the chest, which are real irradiations from those in the abdomen. In a woman one of the breasts, or both, experienced at times a painful contraction, which rendered them harder immediately. Stoll is the first who remarked this. But Tanquerel has not observed, like him, that there was an increase in the size of the gland; far from this, it seemed to him to lessen at the moment of the attack of pain. There are generally other functional alterations than pain to be observed in the respiratory organs.

Respiration is rarely perfectly tranquil during the whole course of violent colic; most frequently, it is temporarily accelerated during the continuance of pains in the abdomen. During the remission, the respiratory movements grow slower till they often return to their normal frequency. In some cases, there have been from sixty to seventy inspirations per minute. This dyspnœa may be caused by the patient restraining his respiration, because it seemed to exasperate the colic pains. Besides, it is not uncommon to see deep inspiration bring on an attack of pain.

Sometimes the inspirations are not only quick, they are often incomplete, painful, noisy, short, the patient complains of a feeling of stifling, and even of suffocation. Very often, and as much as possible, he makes no use of the parietes of the abdomen, for enlarging the chest, the pain prevents it; it has also been observed that the thoracic cavity is with effort dilated to its full size, whilst the abdominal parietes very tense, are scarcely raised. At other times, when respiration is difficult, the motions of the lungs and diaphragm seem themselves constrained, for the patient dilates the abdomen by swelling its parietes so as to facilitate the respiratory movements. Some authors, among others, Illsman, think that respiration is sometimes rendered difficult by the convulsions of the diaphragm. This hypothesis has made them admit a convulsive asthma produced by lead. In some cases, a violent attack of colic abruptly stops, it may be said, respiration, which becomes interrupted, suffocating.

One patient attacked with chronic lead colic, experienced extreme oppression, at the moment when the eructations were very frequently repeated. This individual was then obliged to sit up in his bed and toss his arms to ease his breathing.

Finally, some patients experience palpitations, a little nervous fatiguing cough, and even symptoms analogous to those of angina of the chest. In one individual, at the moment of the exacerbations of colic, the pain arose from the epigastrium to the chest, and extended the whole length of the arm; this person then experienced palpitations, and a very marked feeling of stifling, making from thirty-five to forty inspirations per minute. Desbois de Rochefort and Andral have also mentioned similar cases.

Difficulty of respiration returning by fits, with the exacerbations of colic pains, has been regarded by some authors as veritable asthma, *metallic or lead asthma*.

Sometimes respiration, instead of being accelerated, is diminished. In one case, Tanquerel counted only twelve inspirations per minute. The patient had sufficient control over his respiration to restrain it from fear of increasing his sufferings. All the morbid modifications of respiration that have just been noticed usually appear only when the seat of pain is in the epigastrium.

Voice.— It sometimes happens that the voice of the patient loses a great portion of the intensity of its usual sound, seeming as if stifled. This symptom is generally found more decided in cases of violent colic; it is especially observed at the moment of the attack. It is necessary to know how to distinguish this temporary remittent aphony of short duration, from that continued and persistent one produced by paralysis of the muscles of the larynx. The voice is often interrupted by groans, panting, fast breathing, as in diaphragmatic pleurisy.

There are some patients who dare not speak, or do so only in a low voice, from the fear, well founded or not, of producing a return of the attack of colic. Entirely given up to the pain of their attacks, completely absorbed by it, they scarcely reply to the questions of the observer, or do so as briefly as possible without looking at him.

Jaundice.— Fifty-one times jaundice appeared in the midst of horrible sufferings, without producing any amendment in the symptoms. This jaundice, produced by colic pains, must not be confounded with lead jaundice resulting from a change in the blood produced by lead. In the first case there is simply extravasation of the bile from its usual reservoirs, and expansion of its coloring principle in the liquids and solids of the organism; while in the second, jaundice depends on a direct change of the

blood by lead. The jaundice of lead colic does not differ in its physiognomy from nervous jaundice, or that from a moral cause; it must not then be confounded with legitimate lead jaundice.

Usually, the yellow observed in lead colic is not so decided as that in common or nervous jaundice, or as that produced by an obstacle in the course of the bile. Simple jaundice coincided thirty-five times with pains in the right hypochondrium, fifteen times with pains in the epigastrium, and in four cases, the suffering did not extend to these two abdominal regions.

In other respects, where lead jaundice and lead colic coincided, the earthy yellow tint, characteristic of the primary effects of lead, was not generally more decided during the abdominal disease, than before its development, but it disappeared on the manifestation of the yellow produced by colic pains.

Circulation. — Is it not very remarkable, to see the circulation grow slower, or preserve its normal rhythm, amid the most dreadful sufferings that individuals can endure, and in the agitation consequent upon them? Of the twelve hundred and seventeen patients, six hundred and seventy-eight had from thirty to sixty, three hundred and seventy-six from sixty-five to seventy, and one hundred and twenty-five had from eighty to one hundred pulsations per minute, although there was no inflammatory complication, nor concomitant organic lesions. In the thirty-eight other patients, inflammatory, and other complications accounted for the acceleration of the circulation.

All authors, with the exception of some modern physicians, have observed in lead colic, a diminution of the pulse, or at least, they have noticed that the arterial pulsations were not more rapid than in the normal state.

The pulse, during the first days of the disease, is often slower than towards the middle. Sometimes the pulse rises beyond the normal rhythm after the administration of purgatives.

Hardness of the pulse, such as is observed in no other disease, exists in more than half the individuals attacked with colic. Stoll compares the pulsations to a very fine iron wire, striking the finger with an unequal, slow, vibrating motion. According to him, when the pulse recovers its ordinary frequency and suppleness, it is a sign that the patient is convalescent, and that relapses are no longer to be feared. Tanquerel, like several other authors, has verified this remark of Stoll, in a certain number of cases. Nevertheless the Venetian physician exaggerates

rated, when he said that he observed *no* exception to this law. At the same time with hardness, there is fullness of the pulse.

In twelve hundred and sixty-nine patients the pulse was irregular, remittent. For some moments the pulsations succeed each other with an astonishing rapidity, then suddenly they sensibly diminish, and so on. In twenty-two cases, the pulse was rebounding; in five, undulating. Generally when the pulse is irregular, it is not hard, it often beats from sixty to eighty times per minute, it is rarely slow. This state of the pulse very often coincides with the different difficulties of respiration, which have been spoken of before, but it appears in a large number of cases that are not accompanied by functional lesions of the respiratory organs.

All these states of the pulse disappeared with the colic, or a few days after, and there was no alteration of the valves or orifices of the heart, or inflammation, which could explain these accidents in the arterial circulation. Nothing in the state of the patient, except the influence of lead, could account for it.

In twenty-nine of the patients who were bled, the pulse presented the same characters after, as before the letting of blood, hardness, slowness, and irregularity, which evidently proves that lead exercises a specific action on the circulation.

In some cases a more or less energetic beating of the aorta could be felt and perceived in the epigastrium; these violent pulsations may be prolonged even to the umbilicus.

According to some writers, the pulse is slow and hard in proportion to the severity of the colic. Tanquerel has not always met with this direct relation between the slowness and hardness of the pulsations and the acuteness of the colic. Yet, it is true, that all the modifications of the circulation, that have just been named, are *in general* more decided in violent, than in light colic, though there are some rare exceptions. In thirteen cases of colic where epistaxis supervened, this flow of blood did not vary the intensity and physiognomy of the lead disease. The clot of blood from the vein does not generally exhibit a buffy coat. In only six cases of true, legitimate, simple colic was this change in the blood observed. The serum does not present any appreciable physical alteration; if lead jaundice is observed simultaneously with lead colic, the yellowish aspect of this liquid will be perceived.

Temperature and Sweats.—The skin of patients attacked with lead colic generally experienced no modification of temper-

ature. It most frequently preserves its normal heat. In only fifty-five cases of colic, exempt from inflammatory complication, could be observed, either by the touch or thermometer, a little more decided heat than usual, but it was not accompanied by that sharpness and dryness observed in inflammatory diseases. More or less copious sweats were observed, at the time of this exaltation of heat. A white lead worker among the patients was every morning covered with sweat, he usually perspired very little, his colic was not followed by paralysis; after the abdominal disease was cured, the cutaneous secretion returned to its ordinary limits. This modification of heat and cutaneous exhalation is accompanied by a greater activity of the circulation, and appears at the close or in the middle of the attack of very violent colic, but does not last during the whole course of the disease. Some authors speak of the increase of heat as limited to the abdomen; Tanquerel has never met with this accident in any of his patients unless from complication.

In fifty-eight cases, the patients complained of intense cold, trying every means to warm themselves, and when they were uncovered, they affirmed that the intensity of their pain was redoubled, and yet the skin of these individuals did not feel cold to the touch. Other patients, on the contrary, complained of a very decided sensation of heat, which could not be perceived by the physician. The greater part of the patients say that cold increases the acuteness of the pain.

Common shivering, scarcely ever observed in lead colic, must not be confounded with that muscular agitation which very often characterizes the severe suffering of the patient. This trembling, the fluttering of the ancients, is more decided and more general than the shivering of intermittent fever, and is repeated from one moment to another, especially during the exacerbations of pain. Tanquerel observed only once, at the same time with violent fits of colic, an attack of fever, shivering, heat and sweat, which did not modify the colic.

Strength. — Strength appears annihilated, or rather oppressed by the violence of the pain, for colic has scarcely ceased to torture the patient, when he immediately recovers all his muscular power. It is only after some days of pain that a general breaking down, an extreme fatigue appears, notwithstanding the cessation of colic.

Cephalalgia. — Cephalalgia is not a disease connected with

colic. When it exists, it is the result of other diseases produced by lead, (lead arthralgy, encephalopathy.)

Fever. — The febrile movement or state does not exist in lead colic, unless there is some inflammatory or organic complication. Let it be remembered that acceleration, and unusual frequency of the circulation are not sufficient to characterize fever; to prove the existence of this accident, there should be observed an increase in the heat of the skin, which at first becomes dry and covered with sweat, accompanied by cephalalgia; there is a general uneasiness, lassitude, diminution in the muscular forces, as well as disease of all the functions.

Nutrition. — When colic lasts for some time, a diminution of general nutrition may be very quickly observed, emaciation makes rapid progress, and the patient, if the disease is prolonged for months and years, finally falls into a kind of marasmus, called *metallic cachexy*. Emaciation then becomes extreme, the skin hard, scaly and yellowish, the muscles diminish in size, and are atrophied. Other individuals, instead of being emaciated, are swollen, attacked with anasarca.

Face. — The face has a very peculiar appearance in lead colic, and this is often sufficient to denote the disease. There may be a complete alteration of the features, announcing the sharpest suffering, and greatest anxiety. It is almost impossible to mistake this physiognomy, when it has once been seen, but it is difficult to describe it. It is not simply the shrivelled face of individuals attacked with peritonitis. In the face of the patient affected with lead colic, there are more lively muscular contractions, more abrupt changes, a more marked agitation, in a word, utter confusion. The anguish that it expresses also indicates greater acuteness of suffering. The eyes are deeply sunk in the orbits, or else project from these cavities; they are often surrounded with bluish circles, and, like the other organs of the face, constantly in motion; they are troubled, wandering, and strongly express the different degrees of pain the patient experiences. The nose is slightly pinched, the cheeks hollow; in a word, there is a tension and retraction of the muscles of the face analogous to those of the abdomen. This expression of the face is particularly marked at the moment of the exacerbations, for during the remissions, the change is much less decided, the face is partly composed. The skin of the face and the white of the eye generally exhibit, in a great degree, the earthy yellow tint

characteristic of lead jaundice. In six of the patients attacked with lead colic, without complication, the face was injected; in two of these there was a slight acceleration of the pulse.

Intellectual Faculties.—The character is found as completely changed as the countenance. Patients of the gayest, most indifferent, or most impassable characters, cannot help feeling very great anxiety about their existence. Those attacked for the first time, with colic, are generally plunged in the most violent despair, the most cruel anguish; they resolve to leave their business, the cause of such sufferings. During the remission, when suffering does not agitate the patient, he is excessively languid, extremely dejected. The mind is not usually affected; only the patient subdued by pain, does not make as extensive use of the intellectual faculties as in the normal state. Sometimes, in violent lead colics, after a great number of attacks, the patient overcome by pain wanders for some hours, but all soon returns to its natural order. It is a sympathetic effect of colic, and not the action of lead on the brain.

When patients suffer a long time, whole weeks and months, they sometimes despair and wish for death, the senses become weakened, the face assumes the expression of a maniac, or an idiot.

Sleeplessness.—When colic is very intense, there is almost always complete sleeplessness. There are exceptions to this rule. In some very rare cases, colic is very violent during the day, and almost completely ceases at night; it is not astonishing that the patient then sleeps a little. In certain cases the pain in the abdomen is very slight, and yet sleeplessness is rebellious, absolute. It sometimes happens that after the complete cessation of pain and other symptoms, obstinate and continual sleeplessness remains for several days. In a word, there is not always a constant relation between the intensity of the colic and the degree of sleeplessness.

The symptom that appears first and remains till the last, in lead colic, is pain. In all cases of colic, observed by Tanquerel, pain always commenced the abdominal affection. This fact has not been noticed by preceding authors; all or nearly all say that constipation precedes abdominal pain. This erroneous belief is the result of too superficial examination and interrogation of the patients. Physicians do not usually witness the development of the first disorders in the digestive organs; they can then

obtain information on this subject only from the patient; but practitioners, believing generally, *à priori*, that constipation precedes pain, from their knowledge of the wonderful efficacy of purgatives in this colic, shape their questions to their patients according to this preconceived opinion. But who does not know with what facility the patient is made to say all that they wish? It is not then surprising, that most persons attacked with colic, to whom they say, *You were constipated before suffering in the abdomen?* reply in the affirmative, and so much the more easily, because they have forgotten, at the time they are questioned, a painful sensation in the abdomen, slight, but progressive, to which they originally paid but little attention, but yet, it was the signal of the presence of abdominal disease. Tanquerel, after having witnessed in a large number of cases, the appearance of the first symptoms of colic during his visits to the lead establishments and manufactories, after addressing to the patients in the hospital, in entirely different ways, questions relative to the development of pain and constipation, is certain, that pain in the abdomen *always* precedes constipation and other accidents in colic.

As soon as pain in the abdomen ceases, there is, properly speaking, no more colic. But as long as this phenomenon exists, the disease has not disappeared. The accuracy of this proposition is not generally recognised. A great many physicians still think, from the success attending the use of purgatives in this disease, that by removing constipation they cause pain and the other accidents to disappear. This opinion is erroneous.

The first day of the complete development of colic, by the administration of drastic purgatives, a superpurgation may be obtained, and yet the cure, that is, the disappearance of pain and the other symptoms, scarcely ever takes place immediately. It is usually only after the administration of these remedies for several days in succession that the pain disappears; then there is no more disease, which proves that purgatives attack the pain as well as the constipation.

In some cases of lead colic, even after natural evacuation has been established, the pain remains days, weeks, and months, notwithstanding the frequent and repeated use of drastic purgatives. In cases of lead colic not complicated, in which there is diarrhœa, all the other symptoms remain, notwithstanding the

frequent evacuations. Finally, when colic disappears spontaneously, solely by the efforts of nature, or when it is cured by the aid of other remedies than purgatives, the pain ceases first, then the other symptoms, and, in particular, constipation. When this last accident still remains for some days, which is rarely the case, the patient is none the less apparently cured. He drinks, eats, regains his strength, &c., in a word, he is no longer in a morbid state; all the functions are regular, notwithstanding the presence of constipation. This symptom does not remain more than three or four days after the cessation of pain.

What has just been said of the relative time of the appearance and cessation of constipation and pain, applies perfectly to diarrhœa, when it exists not as a precursor, but as a symptom of simple lead colic, without complication.

Hardness, contraction and depression of the abdomen and testicles exist in a perceptible manner only after the complete development of colic pain. When the latter diminishes, retraction and tension of the abdomen disappear. Nausea and vomiting appear as soon as the pain in the abdomen is manifested, at the same time as constipation; they never remain longer than the pain.

After the cessation of pain, the patients immediately ask for food with determination; digestion soon regains its power.

Eruclation, borborygmi, and hiccoughs, are not usually manifested until after the complete development of pain, and they disappear with it. Hiccoughs generally last only whilst the pain is in its greatest degree of intensity. Borborygmi and eruclations do not cease when the evacuations are in greater or less abundance, if the pain itself is not extinct.

As soon as pain is felt in the hypogastrium and the renal region, difficulty in the urinary excretion and diminution in its secretion become evident. These different accidents disappear very rapidly with the pain, or immediately after; often the urine, previously rendered drop by drop, is evacuated in a large quantity, at one or many times.

Dyspnœa, in various forms of difficult respiration, and aphony, follow in the train of pain in the abdomen, when the pain has reached its greatest degree of intensity. When the pain diminishes, and before its disappearance, the functional alterations of respiration can no longer be observed.

Jaundice never manifests itself until after several days of

intense pain, but it lasts several days longer than the suffering in the abdomen, diminishing continually and progressively from the time when the colic pain decreases in intensity.

If lead jaundice has become more decided on the attack of colic, it generally diminishes after the cessation of pain. But it is only after a long time that it completely disappears. For it is not colic which causes this jaundice, it is one of the direct effects of the presence of lead in the system. The other phenomena of the primary effects have a similar relation to lead colic and jaundice.

Hardness, slowness, and irregularity of the arterial pulsations are only felt when the pain has lasted for one or two days, and when it has reached its greatest intensity. The pulse insensibly regains its suppleness and regularity when the pain diminishes. The return of the circulation to its normal state, indicates the cure of the disease, but not the continuation of convalescence, as Stoll states, for there may be relapses. In some cases, there has been considerable acceleration in the circulation, the pulse beating from one hundred to one hundred and ten times, although the pain and other accidents had disappeared, and frequency of the arterial pulsations had not been observed during the existence of the colic. The cause of this morbid phenomenon, which rarely lasted more than a few days, could not be discovered.

Strength, for a time weighed down, returns with astonishing rapidity. Some patients work hard the day after the disappearance of a most severe colic. Metallic cachexy, if it has not preceded colic, when once this last is cured, promptly disappears. Nutrition is again active with energy, and the organs repair their losses with surprising activity.

Thus all the symptoms of colic are developed only after the attack of pain. As soon as that diminishes or ceases, the other accidents rapidly disappear, and all the functions resume their regular course. The symptoms of colic are generally in proportion to the severity of the pain, and the period of the disease when all these accidents are most decided is the same. Convalescence always shows itself by the cessation of pain, followed by regularity of evacuations and suppleness of the abdomen.

CHAPTER VII.

VARIETIES AND COMPLICATIONS.

THE chief varieties take their name from the seat, or from the degree of pain, and other symptoms. Thus are named umbilical, epigastric, hypogastric and renal colic, according as the disease occupies these different regions. Then, colic is divided into slight, moderate or violent, acute or chronic, terms which, of course, are applicable to the varieties named from the seat of the affection. These last may exist all at once, singly, or combined with one or more of the other forms. Rarely does one form only exist, and occasionally the varieties succeed each other, one ceasing and the other making its appearance.

Acute colic, has formed the type of the description which has been given of this disease, but there are cases, which torment the patient for years, without ever becoming acute.

COMPLICATIONS.

Lead colic may be concomitant not only with other lead diseases, but with maladies arising from causes unconnected with lead preparations. These complications exist independent of colic; they are not in the least influenced by the treatment, yet they modify the character of the colic.

It seldom occurs that colic is the only symptom of the effect of lead on the system. Generally, colic is preceded, or succeeded, or accompanied by arthralgy, paralysis, or encephalopathy, all of which have been already mentioned as precursors, as have also the primary effects. But there are other diseases, which require more particular notice, and especially gastritis, enteritis, peritonitis, and dysentery, which sometimes, though rarely, appear concomitants with lead colic. These diseases modify the physiognomy of the lead affection, and when removed, that appears in all its genuine character.

There are cases of other inflammatory diseases, seated in the urinary organs, as nephritis, blenorrhœa, &c., which may be complicated with colic, without any reciprocal effect. It is to be

remarked, that an epidemic diarrhœa impresses its character on lead colic, and during that year, when the fatal cholera desolated Paris, the number of patients with lead colic admitted into the "Charity" was excessively diminished. The number of cases of colic among white and red lead workers, at the manufactories near Paris, was also much less than in preceding years, and cholera was, in six cases under the notice of Tanquerel, followed by lead colic.

In cases complicated with gastritis, one of two things may happen: either the seat of the pain is in the epigastrium, or it exists in every other part of the abdomen. In the first case, the pain has slightly marked exacerbations, and is sensibly increased by pressure, as well as by the introduction of drink and food. Vomiting is very frequently repeated during the whole course of the disease, eating and drinking provoke its return; it also takes place spontaneously. The patient constantly has a burning sensation in the epigastrium, which, for a moment, changes into a feeling of twisting; his face is then shrunk up, he utters cries, constantly changes his position, rolls in his bed, presses his stomach, &c. The tongue is dry, large, with a thick, whitish coating, under which may be seen a very decided red tint; its tip presents numbers of bristling papillæ. There is an excessive desire for refreshing drinks, in some cases there is anorexy, a marked disgust for all kinds of food. Constipation exists; but the abdominal parietes, instead of being depressed, are swollen, and not contracted. The urine is red and rare. The skin acquires a dry, biting heat; the pulsations are from a hundred to a hundred and twenty a minute. The face injected, the red color of the cheeks mingles with the leaden gray of the other parts of the countenance. The patient complains of cephalalgia, and a feeling of general breaking up.

If the seat of colic is in the umbilicus, or hypogastrium, it is then more easy to separate the local symptoms of inflammation in the stomach, and those of lead disease. Certainly, each of these two diseases is marked in its own place, with its accustomed characteristic phenomena. The general symptoms or reaction, such as the febrile movement, &c., depend on gastritis, and not on lead colic. Sometimes these two diseases follow their accustomed progress, as if each existed alone.

The gastric difficulty that authors say they have often observed as a complication of lead colic, is generally only the simple epigastric form of the lead disease.

When enteritis is complicated with colic, there are symptoms which generally serve to reveal their simultaneous presence. The abdomen is slightly swollen, without being contracted. The pain tends to generalize itself, but is often much more acute in parts, as the hypogastrium and epigastrium; constant and very sensibly increased by pressure, it yet becomes at times much more severe. At the moment of the exacerbations, pressure is less painful, the patient tosses about in the bed, lies on the stomach, rubs the abdomen, &c., if the pains are severe, they are accompanied and followed by alvine evacuations, which give no relief. The ferbile movement, the state of the tongue, as well as all the other general symptoms, are the same as those when gastritis is complicated with colic.

In cases where dysentery and lead colic coincide, there is a twisting, remittent pain, most frequently in the umbilicus, and which pressure, at the time of the attack, slightly increases. During the exacerbations there is a general agitation, the patient utters cries. The face is shrivelled, and of a more or less perceptible yellow hue. There is a painful tenesmus, fatiguing, wringing pains, very numerous stools composed of scybala, and bloody mucous matter, which afford decided relief. The abdominal parietes are uniformly tense and projecting. The abdomen acquires a sensible degree of heat; nausea and vomiting occur, the skin is hot, dry, or damp, and the pulse frequent, the tongue red and dry.

When peritonitis and colic are associated, the following symptoms are observed: The abdomen is tense, bulky, full of gas, or liquids, so sensitive that the slightest pressure produces insupportable pain, which also appears spontaneously, and then does not prevent the patient from constantly changing his position in bed. He then has hiccoughs, vomiting, great thirst, a dry, red tongue, often coated, and constipation. Finally, the pulse is frequent, but neither small nor obscure, as in pure, simple peritonitis.

Typhoid fever, developed in a white lead painter attacked with colic, so disguised the lead disease, that it was impossible to follow its steps. Stoll and Merat have seen bilious, putrid, and malignant fever complicated with lead colic.

In the various inflammatory complications above noticed, it is at once seen, that the phenomena indicate a combination of a local inflammation with lead colic. Drastic purgatives increase

the symptoms of the first, while they are sensibly diminished by antiphlogistic treatment. If removed, true colic sometimes remains, and is cured by remedies which are inefficacious during the complication. Inflammation of the alimentary canal, concomitant with lead colic, is much rarer than is usually supposed.

CHAPTER VIII.

PROGRESS AND DURATION.

LEAD colic, like nearly all diseases, generally passes through several different periods. There is a period of invasion, a period of increase, or station, and a period of decline. But different phases of the disease do not invariably progress by successive and regular steps, nor can their duration always be fixed, as is the case in the greater number of the phlegmasiæ, and lesions, termed organic.

The progress and duration of the period of invasion has been shown in the article on Precursors, and need not here be repeated.

During the period of increase, the characteristic phenomena of colic may be observed in all their violence; the attacks or crises are more decided and frequent than at any other period of the disease. The degree of colic rarely remains precisely the same during several successive days at this period. Sometimes the symptoms increase daily and progressively, until they diminish in an equally gradual manner; sometimes the pain, each day, makes progress of frightful violence till the moment of decrease.

But it is not always so. Very often, during the whole period of the acuteness of the disease, the intensity of the colic varies from day to day, so as to be alternately worse and better. Thus, to-day the colic may be violent, to morrow moderate, or even slight, the day after it again becomes violent, then moderate, light the day following, and so on. Sometimes this variation in the intensity of the pain may be observed at different periods of the day, in the morning or evening, by day or night.

Colic is often more severe towards evening or during the night, becoming calm again at daybreak. This exacerbation of pain

is only observed when the disease has reached its greatest height ; for when it is about terminating by cure, by some other disease, or by death, it is generally evening or night when these terminations take place. In one individual attacked with lead colic its exacerbations appeared at the close of day, continued all night, and disappeared in the morning.

In whatever manner colic progresses during the period of its acuteness, the transition of this latter at the period of decline rapidly takes place. Thus, from one day to another, or even from morning to evening, the disease almost completely ceases. When witnessing, for the first time, the frequently repeated attacks of violent colic, one fears for the fate of the patient, and can hardly suppose that calm will succeed, in a few hours, all this upturning of most of the functions of the system. The patient now only complains of slight pains, constant, or returning by gripes ; in the first case, generally fatigue, weight, or compression, is felt in the abdomen ; in the second case, gases rolling with rapidity in the intestines, occasion, from to time, a painful sensation of distension. Constipation ceases, or has usually ceased, the evacuations resume their usual state, the abdomen regains its suppleness and projection, the sphincter of the anus is relaxed, nausea and vomiting disappear, the gases resume their habitual course, escaping, in part, by the anus ; the appetite returns with energy ; the fetid taste and breath disappear ; the urine flows easily and abundantly ; the pulse recovers its frequency, regularity, and accustomed suppleness ; fatigue, the feeling of breaking down, and general uneasiness, resulting from the violent shock recently given to the whole system, is dissipated by refreshing sleep. Finally, the very day, or the day following, the remains of colic completely disappear ; the patient is cured.

The promptness with which the functions regain all their energy is truly marvellous. Yesterday they were nearly all impeded ; to-day they all go on as if there had been no grave disease. This unhopèd for change is immediately apparent to the physician from the countenance, and lying down of the patient. His countenance has resumed its habitual play, and nearly its normal aspect. Calm and tranquil in his bed, he no longer places himself in those very fantastic positions. He is no longer the same person, every thing is changed.

Sometimes there may be said to be no period of decline. The

colic, arrived at the greatest degree of violence, suddenly ceases; half an hour after the patient has recovered his health, or at least the pains in the abdomen have completely ceased. In some cases of colic, when the disease is in the close, or middle of the period of decline, the pain suddenly reappears with the intensity of the most acute state. The return of these recrudescences cannot generally be foreseen. Sometimes, imprudence in diet, especially nourishment taken too soon, is the cause, as well as fresh exposure to lead preparations. Alternate ameliorations and recrudescences may be observed still more frequently in chronic lead colic. Sometimes the patient is for days and whole weeks free from suffering; then the phenomena of colic return with more intensity than ever.

In short, one of the most astonishing characteristics in the progress of lead colic, is the facility with which it is reproduced, before the patient is again exposed to contact with lead. The circumstances which favor these relapses have already been named. Relapses have often taken place one or many days after the colic was, to all appearance, perfectly cured. In how many cases have the patients, at the moment of leaving the hospital as cured, been suddenly seized anew with the disease from which they thought themselves free!

There is no positive sign, indicating beforehand, that some day the patient will experience a relapse. The characteristic traits of the primary effects remaining in certain persons after they have been cured of colic, indicate only the possibility of a relapse, since lead is always in the system.

Sometimes colic, in a relapse, presents the same physiognomy as that which primitively existed. Sometimes, on the contrary, the attacks are totally different in regard to the seat, acuteness, progress, termination, &c. &c. Sometimes even the relapse of lead disease is no longer characterized by colic; lead arthralgy, paralysis, or encephalopathy, are substituted for the painful disease in the abdomen.

Thus lead colic has no regular and uniform progress and decrease; it proceeds more commonly by bounds and leaps to its greatest acuteness, as well as to its termination.

It may be said, generally, that good treatment considerably opposes the decided alternations that have been noticed in the intensity and form of the symptoms of colic. Unfortunately it is not always thus; but cases are very rare where a medicine,

known to be very efficacious in this disease, does not impede in part its insidious progress. On the other hand, in a few cases of colics left to the efforts of nature, or combatted by means usually inefficacious in the disease, the affection has proceeded in the regular march of those stages that have been mentioned.

The total duration of colic varies infinitely, according to the circumstances, progress, treatment, &c. &c. It would then be impossible and unreasonable to wish to establish limits for it, and to deduce from all the observations that science possesses, or have been collected, a mean duration. To establish such an approximation with exactness, it would be necessary that all the cases should have occurred in the same circumstances; but this not having been the fact, their duration varies very much. The following distinctions must then be established to come to an exact appreciation of the duration of colic.

1. When individuals who have contracted colic, continue, from the mildness of the disease, to work amid the circumstances which occasioned these accidents, the disease lasts indefinitely, if no treatment is opposed to it. Some individuals are sick for whole years. Sometimes, though very rarely, colic disappears of itself in a few days.

2. Suppose now that the patients leave the work that caused colic; in cases of colic left solely to the efforts of nature, it is, generally, impossible to positively fix its duration. It commonly lasts for twelve or fifteen days; for months, or years, or indefinitely. In a few cases, it spontaneously disappears in two, three, seven, or eight days. When it is violent, its duration is generally longer than when it is moderate or light.

3. Most frequently, when the physician is called to treat lead colic, the patient has already been suffering for several days with this cruel pain. The mean duration of colic is then to be dated from the day when the treatment was commenced. It is said, and believed, that there are modes of treatment which abridge the duration of colic. Certainly this is partially true of any curative mode, for all slightly abbreviate colic. The only method of treatment, almost constantly abridging the duration of this disease is the heroic, an active treatment by daily repeated doses of drastic purgatives. This, according to Tanquerel, may crush the disorder in its onset, generally producing a most decided abridgment, the disease disappearing in three or four days after the exhibition of the medicines.

When colic and arthralgy simultaneously appear, rarely do their periods of greatest intensity correspond. They are subject to frequent alternations of predominance, which are often repeated during the course of the disease, the one ceasing and the other appearing and this often occurring suddenly. Colic and paralysis rarely attack together; the first generally precedes the last by some days, and appearing occasionally on the sudden cessation of colic in the midst of its march. There have been however, cases where colic has not occurred till after paralysis has been fully developed. These affections are not subject to alternations of predominance, for one is an acute, the other more a chronic disorder.

Colic generally precedes when complicated with encephalopathy. Colic opens the scene, in the midst of whose acuteness cerebral affections are manifested. Then it is, that sometimes the pain abruptly ceases, or gradually declines; while again it may endure in all its intensity, or even survive encephalopathy. These diseases are also subject to great alternations of predominance. In some instances colic has supervened the cerebral malady.

The attacks of other lead diseases, long and long after colic has been cured, without fresh exposure to their causes, prove that the relapses of lead diseases differ from the primitive onset, where colic appears in concert with the primary effects; these, especially jaundice, increase or become stationary during the continuance of colic, but disappear rapidly on its cessation, particularly if the subject removes from their causes. Colic seldom shows itself till after full development of the primary effects.

It is thus proved incontestibly, that the cerebro-spinal nervous affections are neither symptomatic nor consecutive effects of colic, for they may each reciprocally precede or terminate the other; a view corroborated by the facts taught by the modifications of colic when these other affections appear. All lead diseases, it may then be repeated, are distinct and independent, originating from a common cause.

It may be added, that in colic complicated with inflammation of the *primæ viæ*, the last, especially if chronic, precedes colic. Generally these diseases appear and progress together; the colic being subdued, masked as it were by the inflammation, appears with greater intensity as that is removed.

There is in this complication no alternating predominance,

unless accidentally produced by the renewal of the inflammation by means used to cure colic.

The duration of colic may be much prolonged by complication with chronic inflammation, or organic lesion of the digestive apparatus, which is often increased by the effects of lead, or the means used for their removal. Being removed, the chronic inflammation or the organic lesion continues as before, or increases, or happily, though rarely, disappears.

CHAPTER IX.

DIAGNOSIS.

In order to establish the diagnosis of lead colic, it is of the greatest importance to know the different etiological circumstances that preceded the development of abdominal diseases. A patient comes, complaining of the abdomen; if he works in preparations of lead, or has been exposed to their action in any way, there are already grounds for suspecting the nature of the abdominal disease. If there can be added to this, proof of the existence of lead diseases, immediately anterior or concomitant, arthralgy, paralysis, encephalopathy, primary effects, there will then be a still greater degree of certainty. Yet, it must be acknowledged that these considerations alone, cannot make lead colic positively and directly known. In short, the greater number of diseases of the digestive and urinary organs are developed in those who work in lead, even when they are attacked with primary effects and other lead diseases; for all diseases in a lead worker are not owing to lead, even as all is not cancer in a cancerous person, or gout in a gouty person. It is only by inference that such an opinion could be formed in this case. The cause which has produced colic cannot always be discovered. The elements of the diagnosis must then be derived from the form of the abdominal diseases.

Lead colic is not perfectly similar to any other disease in the abdomen; it is a disease with a peculiar *specific* physiognomy. In short, although it has no peculiar symptoms, yet their *ensem-*

ble, their connection and progress, allow it to be easily distinguished from all affections of the abdomen or neighboring organs. And yet, who would believe, that in Paris, that sanctuary of medical science, the greater part of the practising physicians do not know how to recognise lead colic! They take it for an inflammation of the digestive organs; nay, even for volvulus or hernia!

Tanquerel has often had occasion at the "Charity," to appreciate the results of the antiphlogistic method, in cases of colic, which at first had been treated in the city, according to an erroneous diagnostic. There are an infinite number of diseases having some symptoms resembling lead colic, and which consequently may be more or less easily confounded with it. To these a brief reference will now be made.

Metallic Diseases.

Have the diseases, caused by other mineral substances, any resemblance to lead colic? Three metals and their compounds have the power, by their introduction and absorption, to produce diseases in the digestive organs; these are copper, mercury, and arsenic.

Copper Colic. — Copper and its compounds may give rise to a specific colic, which has some similarity, and some great dissimilarity to lead colic.

In both diseases the patient suffers from severe abdominal pain; but, in the lead disease, it is in a small space situated almost always on the median line, or some point of the abdomen; the renal region and thorax are also attacked. In copper colic, the pain attacks the whole abdomen, but does not extend beyond. Pressure always increases the pain in copper colic; a contrary effect is produced on pressing the abdomen of individuals attacked with lead colic, especially at the moment of the attack. The abdomen is depressed, tense, and contracted in lead colic; on the contrary, in copper colic, it is a little more voluminous and more supple.

The pain in these two diseases is continual and exacerbating; but the cries, agitation, odd positions and expressions of the patient during the attacks of lead colic, impress a characteristic physiognomy on this disease, that is not met with in individuals with copper colic.

Constipation is one of the pathognomonic phenomena of lead colic, whilst diarrhoea, consisting of abundant, slimy, greenish, frequently repeated stools, accompanied sometimes with wringing pains, characterize copper colic. These two symptoms, by themselves alone, may not always distinguish these two colics; for two cases were observed by Tanquerel, where no diarrhoea accompanied copper colic.

Nausea and vomiting are very rare in copper colic, whilst these symptoms habitually form a part of the train of lead disease.

It has been impossible to discover in copper colic that abundant formation of gas, and those eructations, that are so well marked in lead colic.

The fetid breath, sugary taste, and blue color of the gums and teeth do not exist in copper colic.

Anorexy, thirst, and the state of the tongue appeared the same to Tanquerel in both colics. Some observers, who, probably, have seen few or no cases of copper colic, have said that in the one caused by coppery emanations, there was very great thirst; the tongue was red, thick, and dry. In the twelve cases of copper colic observed by Tanquerel with great attention, he did not meet with these symptoms. The febrile movement observed by him in a solitary case of copper colic does not offer a diagnostic. But sedation, firmness, irregularity of the arterial beats in lead colic are not phenomena observed in the other metallic colic. The diseases that have been noticed in the urinary organs in certain forms of lead colic, (lead nephralgy and cystalgy) are not seen in copper colic.

Respiration, sometimes so remarkably accelerated in the disease produced by lead, is not disturbed in copper colic.

The earthy, yellow tint, and emaciation, which indicate a primitive alteration of the liquids and solids produced by lead, have not been seen in copper colic.

Other lead diseases, such as arthralgy, paralysis, and encephalopathy, very often accompany, precede, or terminate colic. Notwithstanding the most minute researches, not the slightest vestige of these diseases could be discovered, in persons attacked with copper colic.

The progress and duration of these two diseases is also sufficient to establish an immense difference between them. It has been shown, that even the most regular lead colic, has an irregu-

lar progress; its different periods do not follow each other by a progressive transition. Its irregular alternations of increase and diminution in intensity, from one day to another, as well as its relapses, have been noticed. Copper colic has no analogy to this in its mode of proceeding; its symptoms increase and diminish by successive steps, so that the duration of its invasion and decline may be predicted, and it is not subject to relapses.

Finally, soothing, mucilaginous drinks, cataplasms and mollifying clysters, baths, and if the symptoms are very intense, bleeding and narcotics have been successfully used in copper colic. It will be seen in the chapter on *Treatment*, that these means are generally useless in cases of lead colic. Yet some intense, well manifested copper colics have been rapidly cured by the usual treatment of lead colic. Thus treatment alone, is not sufficient to distinguish these two colics, as some are eager to announce even at this day. The small number of cases of copper colic occurring in the hospital and in private practice, prevent any thing very positive or certain being advanced, with regard to its proper and differential treatment.

It results, then, from this comparative analysis, that if any one symptom of lead and copper colic is insufficient, in certain cases, to characterize the disease, their *ensemble*, progress, and connection distinguish them from each other. This proposition is the result of positive facts, and not of gratuitous suppositions. It has been said that, in certain cases of lead colic, there is not one of the abdominal symptoms of that disease, with the exception of pain, which is not wanting in some circumstances, or which may not be replaced by a contrary symptom, characteristic, for example, of copper colic.

This difficulty in the diagnosis is very great, and sometimes even insurmountable, in certain cases of colic, with symptoms of slight intensity, and slightly griping, which occur in individuals working at the same time in copper and lead. But then the feebleness of the disease, if other concomitant accidents do not supervene, threatens no danger, which could make it very important to decide in a positive manner whether it was copper or lead colic.

Dubois, in his famous thesis, describes a colic similar to that produced by lead, and which he supposed to be produced by copper. Workmen in the celebrated foundry of Villedieu-les-Poëles, in Normandy, are mentioned by this author, as subject

to the accidents of lead colic, but only one thing is wanting for the exactness of the narrative of Dubois, it is *truth*. This author had not visited this establishment; or he could have seen that the workmen subject to lead colic are only those who work in lead. M. Havard, a descendant of that physician, who was formerly engaged in a controversy with Dubois, assured Tanquerel of this, in several valuable letters that he addressed to him on this subject.

Mercury may produce metallic diseases totally different from lead colic. It is only in the specific inflammation that it occasions on different parts of the digestive mucous membrane, of those who work in it, or take it as a medicine, that it can be compared to colic. The mercurial enteritis is characterized by a very abundant diarrhœa, obtuse and constant pains in the abdomen, increasing by pressure, and accompanied by fever and all the train of mercurial cachexy. Enteritis, or mercurial colic, cannot then be confounded with lead colic.

Arsenic, deposited on a part of the system far from the digestive tube, like lead, produces deleterious effects in the abdominal organs; but these effects have no analogy. The action of arsenic on the digestive tube, in consequence of its absorption, is analogous to that produced, when it is taken directly into these organs. It is impossible to discover the slightest resemblance between lead colic and a disease produced by corrosive substances.

Neuralgiæ of the Abdomen.

Neuralgiæ of the digestive and genital organs present some points of resemblance to lead colic; sometimes the difference is very difficult to seize.

Gastralgia and Enteralgia. — These diseases greatly resemble lead colic. They are also sufficiently different not to be confounded. Tanquerel has marked these differences, in the following table, which represents the symptoms of each of these diseases.

SYMPTOMS.

LEAD COLIC.

Pain violent, acute, twisting.
 " exacerbant.
 " diminishing by pressure.
 " increased after food.
 " generally more violent in the evening.
 At the moment of attack, agitation, cries,
 odd positions.

Constipation, habitual, obstinate.

Evacuations globular (scybala).
 Hardness and depression of the abdomen.
 Tenesmus in the anus.
 Aggravated beatings in the epigastrium.
 No intermittent fever.
 Urine red, dysury, vesical tenesmus.
 Diminution of the urinary secretions.
 Pain in the renal region.
 Tongue covered with a mucous colluvies.
 No appetite.
 Never depraved.
 Eructations, borborygmi.
 No gapings.
 Bilious vomiting.
 Natural heat in the abdomen.
 Ordinary thirst.
 Pulse slow, hard, irregular.
 Emaciation decided and rapid.
 Face pinched, disturbed.
 No cephalalgia.
 Jaundice rare.
 Dyspnoea.
 Neuralgic pains in the lower limbs.
 Paralysis of the extensor muscles.
 Delirium, epilepsy, coma.
 Amaurosis.
 No fainting.
 Duration very short, a few days.

Progress rapid, complete cessation of the
 accidents.

Physiognomy changeable.

GASTRO-ENTERALGY.

Pain violent, keen, tearing.
 " intermittent.
 " diminishing by pressure.
 " less violent after food.
 " appearing more often in the morning.
 During the attack, little anguish.

Constipation frequent, easily overcome.
 Followed suddenly and without cause by
 diarrhoea.

Evacuations natural.
 No hardness and depression of the abdomen.
 No tenesmus in the anus.
 Aggravated beatings in the epigastrium.
 Intermittent fever.
 Urine clear, easily excreted.
 Urinary secretion, natural.
 Absence of pain.
 Tongue discolored, large, clean.
 Appetite often increased.
 Often depraved.
 Eructations, borborygmi.
 Frequent gapings.
 Mucous vomiting.
 Alternations of heat and cold in the abdomen.
 Ordinary thirst.
 Pulse feeble, slender, irregular and frequent.
 Emaciation hardly perceptible and slow.
 Countenance hardly altered.
 Cephalalgia.
 Jaundice rare.
 Dyspnoea.
 No neuralgic pains in the lower limbs.
 No paralysis of the extensor muscles.
 No delirium, epilepsy, coma.
 No amaurosis.
 Faintings, syncope, &c.
 Duration very long, weeks, months, whole
 years, indefinite.
 Progress slow, frequent appearance, and
 return of the accidents, sometimes
 periodical.
 Physiognomy of the disease less variable.

There are some neuralgiæ coming with other nervous diseases, which may be so much the more easily taken for lead colic, because they have some points of resemblance to the lead accidents which are developed in the cerebro-spinal nervous centre.

Hysterical or Nervous Colics. — Women subject to hysteria, experience severe colic pains, diminished by pressure, accompanied

by constipation, and frequent eructations. These patients complain at the same time of acute pains in the limbs. Several observers have seen paralysis of the lower limbs ensue in consequence of such colics. Temporary amaurosis, delirium or coma, have also been noticed in these circumstances. But in this disease, there is no alteration in the urinary functions, the pulse is small, firm, and neither hard nor tense, as in lead colic.

Hysteric colic, exasperated by the least emotion, is not accompanied by depression of the abdomen, on the contrary it is swollen. There is neither nausea nor vomiting. When this colic does not exist alone, independent of every other symptom of hysteria, the patient experiences the hysteric ball, as well as convulsions which do not resemble lead convulsions, though they are sometimes developed during lead colic.

Finally, the efficacy of narcotics in hysteric colics, and their very frequent failure in lead colic, serve to establish still another diagnostic difference.

Inflammation of the Abdominal Organs.

In the eighteenth and nineteenth centuries, efforts were made to confound lead colic with inflammations. But to make this fusion, it would be necessary that lead colic should resemble the diseases with which it was to form an alliance.

Gastritis and gastro-enteritis are, according to the report of these physicians, (Bordeu, Broussais, Palais, &c.,) phlegmasiæ to which lead colic ought to be assimilated. Yet what great differences separate these diseases! In phlegmasiæ of the digestive tube, the pain is fixed in one part of the abdomen, continual and less acute than in lead colic. It is constantly increased by pressure in the first of these diseases, and the patient, far from being agitated and restless, lies calmly in bed, conscious that motion would increase his sufferings. The abdomen in individuals affected with gastro-enteritis is swollen, hotter than in the normal state, and painful to a much greater extent than in lead colic; when it is tense, it increases in size; the contrary takes place in lead colic.

In gastritis, constipation is slight; enteritis is almost always accompanied with diarrhœa, and there is no painful tenesmus.

The mildest drinks, taken even in a very small quantity, increase the pains of gastritis, and consequently excite vomiting. Food excites with still more energy pain and vomiting. The tongue is red, and dry; there is disgust for food; thirst is extreme, the patient eagerly desires refreshing drinks. Cephalalgia, lively injection of the face, general uneasiness, and some fever, are found in phlegmasiæ of the digestive tube. The urine is red, sedimentary, secreted in small quantity, and evacuated with the greatest facility; and there are none of those frequent, but unsatisfied desires to evacuate urine, as in individuals attacked with colic. Neuralgia of the limbs does not accompany gastro-enteritis; the patient complains only of bruising. Tanquerel observed in a very few cases of inflammation of the digestive tube, paralysis, delirium and convulsions; but these diseases have not the physiognomy of those produced by lead. The symptoms of lead colic are hardly calmed before the appetite is renewed; immediately after the cure, which takes place in a few days, the patient may resume his usual diet with impunity; convalescence in gastro-enteritis is always slow, and the least departure from the established regimen may provoke a return.

Dysentery, Colitis.—Inflammation of the large intestine must not be confounded with lead colic; for in the first of these diseases there are always wringing pains and bloody mucous stools; whilst constipation is, next to pain, the most constant character of the disease produced by lead. In dysentery, the pain follows chiefly the track of the colon, which has never been found in lead colic to be exclusively painful. Finally, the differences that exist between lead colic and gastro-enteritis, also distinguish these two diseases. Some authors say that they have seen a paralysis, analogous to that observed in lead colic, supervene in consequence of severe dysentery. Did not the cases in which this consecutive phenomenon was observed, belong to vegetable colic which frequently produces it, rather than to dysentery? (Chomel et Blache, *Art. Dysenterie* du Dict, en 25 vol.)

Peritonitis.—This inflammation has nothing in common with lead colic, except vomiting and constipation; but the tension, swelling, and extreme sensibility of the abdomen, the smallness and frequency of the pulse, the heat of the skin, and absence of the other symptoms of lead colic, establish a decided difference between these two diseases.

Lead Colic complicated with Phlegmasiæ of the Digestive Tube.

It is not always easy to discover the union of these two diseases. This difficulty is particularly felt when the abdominal symptoms are but slightly marked and determined. Often it is only the first appearance, the farther progress of these diseases, and the influence of the treatment, that reveal their simultaneous presence. What still serves to establish the diagnosis of lead colic, when complicated with an inflammation of the digestive organs, is the frequent development of other lead diseases. This sign alone would not be sufficient, for other forms of lead disease, independently of colic, may exist in a lead worker attacked with pure, simple intestinal inflammation.

Nephritis and Cystitis.—The functional alterations which take place in, have been taken for inflammation of the urinary organs, by inattentive and inexperienced observers. Yet the constant pain in the hypogastrium and renal region, increased by pressure; the physical and chemical change of the urine; different products of new formation, such as pus, &c.; also the febrile movement, which characterizes nephritis and cystitis; are perfectly sufficient to distinguish them from the hypogastric and renal forms of lead colic.

Liver.—When a person attacked with colic, feels pain particularly in the right hypochondrium, and jaundice supervenes, it might be mistaken for a case of diseased liver, if all the other symptoms of lead colic did not exist, and if the pain in the hypochondrium did not vary in intensity and situation from day to day.

Organic Lesions of the Abdomen.

It might be thought *a priori*, that it is impossible to confound an organic lesion of the abdomen with lead colic. This diagnostic error has nevertheless been committed by one of the most skilful French physicians, and also by Tanquerel himself. A color grinder was received into the Hospital of Charity, for violent pains in the abdomen, attributed by him to the influence of his profession. These pains occupied the whole abdominal and renal regions. They consisted in a feeling of dilaceration, which, at times, became so outrageous that the patient uttered frightful cries.

During the exacerbations, this man, excessively agitated,

pressed the abdomen with his hands, constantly changed his position without finding any relief. During the remission, the pain consisted only in a feeling of pressure; the abdominal parietes were retracted, and hard as stone; frequent vomiting fatigued the patient. For four days, he was often tormented with a desire for evacuation; and yet he said he was completely constipated. Urine flowed in as great abundance, and as easily as in the normal state. There were very frequent eructations. The pulse depressed, regular, beat sixty-five times per minute. The skin was of the normal heat, and the tongue in a very fine state. The patient also complained of acute exacerbant pains, and also of cramps in the calves of the legs and soles of the feet. The preceding night the pains were so violent that the unhappy sufferer was delirious for some hours.

All these symptoms appearing to characterize lead colic, a drop of croton oil, and the purgative "painters' clyster" were prescribed. The next day, the symptoms being aggravated, the patient was asked if he had had an evacuation; on his replying in the negative, a second drop of croton oil was about to be prescribed, when the nurse brought the vessel which the patient had used ten or twelve times during the night; a small quantity of mucous bloody matter was there perceived.

An examination of the abdomen was made again with much care; a very hard tumor was found occupying the left side of the large intestine. The least pressure on this point, caused the patient to utter loud cries. From this time, treatment by drastic purgatives was abandoned; the use of the cupping glass was prescribed for the region occupied by the tumor, the probable cause of all the symptoms. The following day, leeches, the use of the cupping glass, and laxative clysters overcame the morbid phenomena, with the exception of the tumor on the left side. This last made gradual progress, and terminated in the death of the patient six months after entering the hospital. On the autopsy, part of the descending colon was found transformed into a cancerous tumor. Traces of former peritonitis existed all around this tumor. The exacerbations of pain in this man appear to have been produced by some points of peritonitis being developed in the region of the tumor. Perhaps also lead colic and the cancerous tumor existed simultaneously. This person said he had only suffered for fifteen days; the pains reached their greatest intensity the evening he came to the hospital.

Inguinal, and crural hernia, especially when they are strangulated, occasion, like lead colic, nausea, vomiting, borborygmi, hiccoughs, and constipation. But in strangulated hernia, vomiting is combined with evacuation, the abdomen is swollen, excessively painful on the slightest pressure. The tumor which occasions all these symptoms may be discovered by the touch; the patient is considerably prostrated; the face is pale, the forehead and anterior part of the breast are covered with cold sweat; the pulse is small, quick, obscure, wiry, &c. All these symptoms form a broad line of difference between hernia and lead colic. It is nevertheless prudent, in examining a patient who appears to be attacked with lead colic, to examine immediately the normal openings of the abdominal cavity, so as to be sure that hernia does not contribute to the symptoms that are presented.

Ileus, (internal strangling, volvulus,) has, in its symptoms, a more marked resemblance than hernia, to lead colic; it is nevertheless very easy to establish the differences between ileus and the lead affection. The pain has not the same character in the two diseases; in ileus it first occupies one fixed point in the abdomen, and it sometimes seems to the patient that the intestine is agitated with violent convulsions; the abdomen is swollen and tense; the patient at first vomits only mucous and biliary matter, but he soon rejects the clysters, and even stercoraceous matter is thrown up; the skin is hot and dry, the pulse small, irregular, intermittent, cold sweats and faintings follow, and the patient sinks in a short time. The occasional cause of this affection is a strangling, or perhaps, an obliteration of the intestine.

Worm Colic. — The presence of worms in the digestive canal of a lead worker, may resemble lead colic to a certain degree. It is well to know that these animals cause colic pains, accompanied by constipation, nausea and vomiting. But the symptoms are less acute than those which characterize lead colic, and they are not so variable in intensity and physiognomy from day to day. The patients, far from losing their appetites in worm diseases, are voracious, for they experience relief after eating. Finally, the appearance of worms in the matter vomited and evacuations, and the cessation of the symptoms in consequence of this evacuation, leave no doubt as to which disease exists.

Stercoral colic, caused by an accumulation of the excrements

in the intestines, produces pains which in acuteness are analogous to those in lead colic; but, in this latter disease, they are seated on the median line, whilst in the former, they occupy the abdomen and anus. Pressure, or odd positions, appear to relieve the patient in both diseases. When the abdomen of individuals attacked with stercoral colic is touched or struck, hard, round, unequal tumors formed by the hardened matter are easily discovered; nothing of the kind is seen in lead colic; tumors are indeed observed in the abdomen, but they are of a different nature, appearing and disappearing, from one moment to another. When the finger is introduced into the rectum of individuals attacked with stercoral colic, excrements may be discovered in the lower extremity of the intestine; while, in lead colic, alternations of constriction and relaxation would be experienced. There is no functional difficulty in the urinary organs in stercoral colic; obstinate vomiting is rarely observed; the pulse preserves its normal regularity and frequency; sometimes it is wiry and frequent. Finally, it must be remembered, that these accumulations exist particularly in sedentary persons, women, and aged men, whose intestines have lost the energy necessary for the evacuation of the excrements.

Lherminier, received into his ward, in 1833, a house painter, aged forty-five years, who complained of dreadful pains in the abdomen, which pressure slightly diminished. The pain was felt most in the iliac fossæ, and radiated towards the hypogastrium. The urinary secretion was as abundant as usual, and its ejection was easy. There was neither nausea nor vomiting; the patient asked with eagerness for food; the tongue was dewy, large and moist; digestion was very good, only the pains became more acute five or six hours after each repast. The pulse was supple, regular, beating sixty-five times per minute, and no traces of other lead diseases could be discovered.

Lherminier, according to his custom, prescribed the treatment of the "Charity," but, seeing that the patient on the third day experienced no relief, he began to examine the abdomen by touch. On the spot where the pain was most acute, he discovered, to his great astonishment, and pointed out to Tanquerel, in each iliac fossa, rounded tumors, slightly doughy, which did not move from place to place. Lherminier, strong in his discovery, prescribed a drop of Croton oil, morning and evening; the next day the pain had completely disappeared, but the

patient had been eighteen times to stool, and had evacuated a considerable quantity of very fetid black matter. This man had never been attacked with lead colic.

Nephritic and Hepatic Colic.—When calculi are formed in the urinary and biliary passages, they produce severe pains in the abdomen and renal region, radiating to the testicles and thorax. Pressure relieves this pain, which becomes more violent by paroxysms; during the exacerbations, the patient writhes in his bed, throws himself on the floor, utters cries, &c. The calculous disease excites nausea, vomiting, and eructations; there is constipation, dysury, and vesical tenesmus. The pulse preserves its suppleness and regularity; sometimes it is depressed and becomes temporarily irregular. These symptoms last for a few hours, or a day, going and coming. They greatly resemble those in lead colic. But, in hepatic and nephritic colic, the patient after much suffering is suddenly relieved by the expulsion of a stone in the evacuations or urine. Previously, such colics had always ceased on the evacuation of stones; or rather the patient often evacuated gravel without pain.

In persons affected with hepatic colic there is a very decided *green* jaundice, and in nephritic colic, if the symptoms continue, the abdomen is swollen. Sometimes organic lesions of the liver and kidneys coincide with the development of the biliary and urinary calculi, causing a tumor, that can be discovered by the sight, touch or pressure. Finally, in these calculous diseases there is no hardness, vibration and slowness of the pulse.

The comparison just made between lead colic, and all the other diseases which have any points of resemblance to it, proves, incontestibly, that this affection is, as Stoll said, *specific*, that it has a characteristic physiognomy, progress, and duration, even when its cause is unknown. Lead colic is then a disease like no other.

CHAPTER X.

TERMINATION AND PROGNOSIS.

TREATED properly and in time, lead colic often terminates by the return of health in a few days. Left solely to the efforts of nature, or combatted by means whose salutary influence is doubtful, this affection also ends in cure, but only in certain cases, the precise number of which it would be difficult positively to enumerate. Tanquerel knew of only one case of simple, legitimate, lead colic which terminated by death. This case was observed and published by him some years ago. (*Journal Hebdomadaire, année, 1836. N. 28.*) The individual who was the subject of this observation, was for three months tormented with violent colic pains. All the treatment recommended for this disease was employed without success; this unfortunate being, arrived at the last degree of metallic cachexy, finally succumbed to a species of painful consumption.

In all the other cases of colic, reported by authors, or observed by Tanquerel, when death ensued, it was almost always the result of lead paralysis or encephalopathy, and not of the symptoms developed in the abdomen. In all other cases of death, where there was no complication of either of these diseases just named, affections foreign to lead always produced this fatal issue.

From a collection of all these cases, it has been determined that out of four thousand eight hundred and nine individuals attacked with lead colic, eleven hundred, about one in forty-three, died. But in all these, with one exception, there was, at the same time with colic, lead encephalopathy or lead paralysis of the respiratory muscles; or, in short, some disease foreign to lead, which was the direct cause of the fatal termination. Colic by itself did not occasion death in the aforesaid cases. Therefore, the approximation of mortality, given by former authors, is erroneous. They have only indicated the amount of mortality in other lead diseases accompanied by colic, and diseases foreign to, but complicated with the lead affection. Lead colic is then by itself not a grave disease, and does not endanger the life of

the patient. But, nevertheless, since in an individual attacked with this affection the deleterious principle exists, which may at any moment act on the nervous cerebro-spinal centre, and there cause diseases often fatal, one should not be without anxiety as to the final issue of the poisoning, even when its existence is only revealed by colic.

About one fourth of the cases of colic terminate in encephalopathy. These are always fatal. So likewise is colic terminating in paralysis of the respiratory muscles. It is the supervening disease only which causes death.

The circumstances which favor, at the termination of colic, the development of other and fatal lead diseases, which are then terminations of the poison, but not of colic, may be now briefly examined.

This termination is particularly to be apprehended in cases of chronic colic. The lead by its long sojourn, having taken, as it were, right of settlement in the system, it may at any moment extend its sphere of action to the nervous centres, whose normal exercise is so necessary to the maintenance of life. Thus all the different influences which may retard the cure of colic, render by that even, its prognosis grave, since they may contribute to the development of lead encephalopathy or paralysis of the respiratory muscles.

When colic, instead of being indefinitely prolonged, abruptly ceases in the midst of its course, or before the usual time of its mean duration, it is very common to see grave effects produced on the nervous cerebro-spinal centre, in consequence of a kind of metastasis.

Relapses very often declare a grave prognosis; for they prove what a powerful action lead exercises on the system, and consequently how easily it may attack the brain, &c. Sometimes also, it happens, that the relapse of lead disease does not display itself as in the first attack by colic, but other lead diseases, such as encephalopathy, are then manifested.

Is the colic of recidivation more dangerous than that which was developed the first time? Nothing positive can be established in relation to this question. Tanquerel has seen colic in both cases become chronic, relapse or mix with other forms of the most dangerous lead diseases.

There are circumstances in which colic is developed which seem to contribute to increase its danger. When the disease is

contracted in a room filled with very abundant emanations, the lead being introduced into the system in a very large quantity, a less speedy termination is to be feared, and a more certain facility for the extended action of the lead, as it is accumulated in the solids and liquids.

The violence or lightness of the symptoms only makes the prognosis more or less unfavorable. There are nevertheless cases of very intense colic, which terminate in a happy and speedy manner; whilst some light colics have an unfortunate issue, and long duration, every thing else being apparently equal. To what can this difference be attributed? Tanquerel has not observed that colic was more or less serious, according as it appeared under such or such circumstances. After an attentive examination of a great number of observations, Tanquerel has not seen that vomiting, and greater or less constipation of the bowels, foretold a fortunate or unfortunate issue, and that the treatment would sooner or later be crowned with success.

Treatment causes the prognosis to vary considerably. Certain medicines often relieve in a few days, and consequently the duration of the malady being greatly abridged, there is less chance for lead diseases of the brain and spinal marrow supervening at the close of colic. Yet, it is necessary to say, that there are unfortunate cases, where, notwithstanding the most favorable appearances, one is deceived, the issue is fatal. Sometimes colic progresses very rapidly by good treatment towards the cure, and its termination is mortal lead encephalopathy, or lead paralysis of the muscles of respiration. Finally, in some cases, happily very rare, colic offers a very grave prognosis, because no treatment succeeds in arresting the course of the disease. Whilst the affection is limited to the abdomen, the danger to the patient will not be so great, or at least his life is not generally endangered. But it is to be feared that the lead may finally attack other organs, as the brain, which would induce serious results, often ending in death. Such are the powerful circumstances which very often enable one to see the unfavorable issue of lead colic, by aiding the development of other forms of lead disease. Generally the prognosis is excessively insidious.

The prognosis is sometimes very grave in cases of colic, complicated with inflammation, or organic lesion of the digestive and urinary organs. Generally, after the complication is overcome,

which is sometimes difficult and even impossible, colic can be cured. Sometimes the treatment for one of two affections increases the seriousness of the other, and what is gained in one is lost in the other disorder. The more fortunate cases are where colic removes the inflammatory phenomena which had previously existed, but here, the ordinary treatment for colic has been used.

Other maladies foreign to lead, which are complicated with colic, and not seated in the abdomen, are not in general more dangerous than when developed in persons not attacked with colic. Yet in some cases the treatment of both diseases cannot be made to keep pace; this retards the cure of colic, and consequently facilitates the development of other lead diseases.

Colic, according to some authors, only terminates by a return to health, another lead disease, critical accidents, or death.

The morbid phenomena that have been pointed out, either by authors, or observed by Tanquerel, during the course of colic, are not regarded by him as critical. The cure of colic does not coincide with the instantaneous appearance of these symptoms. These are simple complications, and not critical phenomena. These reflections apply equally well to paralysis, which some authors have considered as a crisis of lead colic.

CHAPTER XI.

ANATOMICAL ALTERATIONS.

PHYSICIANS who have attempted to trace the history of lead colic, or simply to collect a certain number of observations on this disease, have made numerous researches, to assign to it anatomical characters. All the solids of the system have been examined to find material alterations caused by this affection. But these efforts have been fruitless, and these attempts useless, no observer has yet been able to discover a constant organic lesion, which could be regarded as the anatomical character of this disease. When some authors say that they have found such or such an anatomical alteration, it is often only to make

these pretended cadaveric lesions agree with the theory that they have adopted relative to the nature of the disease.

The result of a slight investigation of all the post-mortem examinations reported by Bordeu, proves that this observer did not know how to recognise the grossest alterations in the dead body, and confounded under the name of inflammation an infinity of anatomical, vital, and cadaveric lesions, differing much in several respects. Generally, instead of describing the lesion that he had under his very eyes, he pronounced the word *inflammation*, so that the reader may conjecture as to the cause, if he is not deceived, which is probable; for when he describes the morbid state of an intestine, he commits the greatest blunders, mistaking a blackish cadaveric congestion for gangrene, &c. &c.

Yet these lame and badly observed facts have been again reproduced in later times by some authors, (Palais,) to prove that lead colic is anatomically characterized by inflammatory alterations.

If a physician in these days published such observations, who would credit their exactness? No one, certainly; especially when physicians, at this period, versed in the researches of pathological anatomy, have been unable to discover the slightest traces of inflammation in persons who died of lead colic, (Merat, Lherminier, Andral, Orfila, Chomel, Louis, Corbin, Grisolle, Martin Solon.) Dehaen, the great partisan of antiphlogistic treatment in this disease, now under consideration, has not found the intestines inflamed in individuals of whom he made the autopsy. And yet such alterations would have marvellously agreed with his therapeutical theory. But Dehaen was a man of honesty as well as a great observer; this is evident in his excellent dissertation on painters' colic.

Some of the cases reported by Bordeu as lead colic, are nothing but enteritis, or peritonitis, which were developed in lead workers.

If traces of phlegmasia were found in individuals who had succumbed during lead colic, it might then be affirmed positively, that inflammation had complicated the lead affection during life.

In forty-nine post-mortem examinations by Tanquerel, of lead colic not complicated, in twenty cases there was no alteration in the digestive tube, or only some traces of congestion, such as were found in most of the subjects whose autopsy he performed, and in whom, during life, no functional lesion of the digestive organs could be discovered. In five cases was found partial

softening; without other alteration, in the most declined parts of the digestive tube. (See Tanquerel's *Recherches sur les Caractères Physiologiques et Anatomiques des Congestions et des Inflammations*. In 8°, 1838.) Cadaveric lesions were observed in an infinite number of subjects. It may then be said, that in these twenty-five autopsies there was no anatomical lesion revealed by the symptoms observed during life.

Six times the digestive tube was found thickened, partially, or through its whole extent. This is an anatomical lesion frequently met with in every autopsy.

Hypertrophy, or the considerable development of the glands of Brunner, was observed in seven cases. Peyer's plates were also found more developed in three cases. In cholera there is the same extraordinary development of the glandular apparatus of the intestine. This anatomical lesion cannot then be regarded as a special characteristic of lead colic. It can only be considered as a consecutive lesion, as it is not formed in all cases of colic.

A subsidence (*tassement*) of the mass of the intestines was noticed in sixteen cases. Dehaen, Leroux, and Merat, have explained the origin of this sinking (*affaissement*) of the intestinal circumvolutions by a contraction of their parietes. This explanation is entirely hypothetical, for Tanquerel has seen slight tractions or insufflations cause this diminution in the calibre of the intestine, to disappear.

Tanquerel regards this state of the intestines as one of the anatomical characters of lead colic, for he has never found it so decided in any other disease, and yet he has noticed this sinking of the intestinal circumvolutions in only a third of the autopsies, which proves, in his opinion, that it is one of the effects of colic, and not the cause of the symptoms observed during life. It may then be wanting in many cases, for it is well known that anatomical alterations, which are the effects, and not the causes of a disease, are very inconstant.

The same observation applies to four autopsies where the intestinal mucous membrane was found covered by a bed of thick mucus, as if coagulated, which kept the excrements of the large intestine adhering. This lesion of the secretion is an effect of the disease, and not the anatomical cause.

Finally, the greater development of the great sympathetic ganglions has been observed *only once*; this ought to be considered

merely as an effect, and not as the anatomical cause of phenomena observed during life.

In all the autopsies the kidneys and bladder were found nearly in the normal state; for some arborisations of the organs did not constitute a morbid alteration. In two cases where there was considerable sinking of the intestinal bundle, the bladder seemed as if shrunk within itself, it had so little volume.

After all these investigations it may be affirmed, that there are no anatomical alterations, perceptible to the senses, which produce all the pathological phenomena of lead colic, and that the material alterations that may be found are only effects, and not causes, of the symptoms observed during life.

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CHAPTER XII.

CHEMICAL RESEARCHES.

CHEMISTRY has endeavored to aid the pathological anatomy of lead colic, by attempting to trace the metal in the liquids and solids of the body.

The earlier observers, little skilled in rigid rules of analysis, and without tact, are little worthy of notice; and when they assert, as Wilson and Dubois do, that lead powder has been seen in the intestines, there is evidently some mistake of observation. This supposes colic to be produced by simple contact of lead with the mucous membrane, and not by absorption. So also Spangenberg pretends to have seen the feces of colic patients covered with litharge, thus confounding colic produced by irritation with that by absorption. Merat first attempted with Baruel to detect lead in the system of lead colic patients, but his efforts were fruitless, because crude and imperfect.

Very lately, (1838,) Orfila has shown that lead preparations given to animals as a poison, could be discovered in the mucous membrane after two hours, but no traces of lead, after four days from the time of its administration. The lead had been absorbed and poisoned the animal. It is surely very important to determine the presence of lead in the blood, and in the more distant

organs of the body, where it appears to have been carried after absorption.

This investigation is admitted to be attended with great difficulties, but shall the attempt be therefore abandoned, which, crowned with success, may throw great light on many maladies? Tanquerel has called to his aid expert chemists to resolve this question.

MM. Tiedman and Gmelin administered acetate of lead to many dogs, and found that salt in the mesenteric and splenic veins. This was an indication that chemical reagents might detect lead in the blood of patients with lead colic. With this view, Tanquerel sent to Chevallier the blood from the vena cava, and right heart, and from the vena portæ, of a patient who had died of lead colic; but Chevallier detected no trace of lead in the *serum*.

Guibort examined the urine of twelve of Tanquerel's colic patients, but detected no lead by the processes he adopted. Tanquerel repeated this mode on the saliva of his lead patients, who had been so long removed from contact with lead particles, as no longer to perceive the styptic taste, &c., in the mouth, but no lead was traced in the saliva. It has already been shown, that the blue gray matter which covers the teeth and gums of many lead workers, consists of sulphuret of lead.

Devergie, having detected by a more refined process than those before used, both lead and copper in the intestines of individuals unconnected with lead preparations, undertook the analysis of several parts of the body of a patient who had died of lead colic, arthralgy, and encephalopathy, which were sent him by Tanquerel.

The following organs were examined, — stomach, intestines, their contents, gall bladder and bile, kidney, urinary bladder, lungs, brain, muscle, blood. All, including even the blood, afforded traces both of lead and copper.

But the result is remarkable for the excess of lead above copper, especially in the intestines. The reverse is the rule in subjects, who have not been exposed to lead emanations, or preparations. The lead in the intestines was seven or eight times greater in amount than the copper. The same remark applies to the blood; ordinarily four and a half pounds of blood give scarcely a trace of lead, while that metal is easily traced in seven ounces of blood in the colic subject.

It is truly quite important to have determined the presence of lead in organs presumed to be the seat of lead colic.*

CHAPTER XIII.

SEAT AND NATURE.

WHEN, in a disease, pathological anatomy reveals after death the material cause of the phenomena observed during life, its seat may be established with certainty, on the point where the anatomical have coincided with the functional lesions. But, in affections like lead colic, where the physician, scalpel in hand, can find no organic alteration, which may constitute a constant character, he is then obliged to have recourse to reasoning and observation on the vital disorders, to discover the seat of the malady.

It has been seen in the chapter on *Symptoms*, that in all cases of lead colic, there were different difficulties in the digestive organs, twisting pain, corresponding to the intestines, constipation or diarrhœa, contraction of the abdomen, nausea, vomiting, formation of a great quantity of gas, tenesmus in the anus, hiccoughs. It is impossible not to know that these symptoms are the result of a functional lesion of the whole digestive tube, from the stomach to the anus. In short, how can it be known that an organ is diseased, if not by the disturbance of its functions?

The organs for the secretion and excretion of urine, are often the seat of the characteristic symptoms of lead colic; pain in the vesical and renal regions; vesical tenesmus, difficult and painful emission of urine, and diminished secretion.

Pains and contractions in the penis, testicles, spermatic cord, vagina, and uterus, with different functional troubles, indicate, with certainty, that the organs of generation may be the seat of the symptoms observed in lead colic.

* See the remarks in the Appendix on this subject, with other and later analyses of the organs of lead-diseased subjects, in the paper "On the Existence of Lead in the Human System," by S. L. D.

Who can doubt the alteration in the functions of the biliary apparatus, when, in consequence of violent pains in the epigastrium, or right hypochondrium, the coloring principle of the bile tints the liquids and solids of the system with yellow?

Thoracic pains, and different difficulties in respiration, sometimes accompany the other symptoms of colic. In this case, can it be denied that the seat of the disease is partly towards the diaphragm?

Thus lead colic is characterized by functional alterations of all the organs, to which the great sympathetic nerve is distributed.

All the pathognomonic symptoms of lead colic may be summed up thus; an exaltation of sensibility; and a perversion of the contractility, and secretions of the organs, of the abdomen. But, it is the nervous ganglionic system which gives them feeling and motion. It is necessary, then, to seek the nature of this lesion of the grand sympathetic.

A study of the symptoms, progress, duration, termination, and treatment, proves that this affection is of a neuralgic nature. In diseases, called neuralgic, pain is the characteristic symptom of those affections; it is very sharp, subject to exacerbations, and is even intermittent; pressure, far from increasing, relieves it; it generally follows the track of some of the large nervous trunks. After death no material lesions can be discovered on the points which were painful. Substances which excite lively perturbation in the nervous system, or by calming it, cause all the symptoms to disappear.

The most characteristic functional alteration of lead colic, is exaltation of sensibility in the diseased organs, which is increased in this affection in an extraordinary degree. This symptom masters all the others. As in all neuralgias, pain in lead colic increases at intervals, returns in crises, and is diminished by pressure; its seat is principally and almost entirely in the parts corresponding to the plexus, and the ganglions of the great sympathetic, the epigastrium, umbilicus, hypogastrium, and renal region; the scalpel reveals no constant, material lesion, either in the digestive and urinary organs, or in the great sympathetic. Finally, a disturbing, energetic treatment, has the most influence on the pain and other symptoms.

When the sensibility of an organ, greatly exalted, constitutes the larger part of the disease, it is rarely that the other functions

of this painful organ are not perverted. Thus in facial and sciatic neuralgias, the mobility and secretions of the diseased parts are modified. The muscles become painful, can no longer be the instruments of regular motion, because the nervous fibres no longer communicate to them a normal influx.

The agitation of the nervous transmits itself to the muscular fibre; hence arise irregular, spasmodic contractions and cramps in these neuralgias. Is it then surprising that the very acute pain in lead colic is accompanied by irregular contractions, similar to convulsions, through the whole extent of the organs composed in part of muscular fibres? How can one fail to recognise, that irregular, spasmodic contraction of the muscular fibres of the digestive tube; the hardness and tension of the abdomen; those hard, unequal, movable tumors, which are particularly evident during the exacerbation of pain; tenesmus; the energetic constriction of the rectum, sphincter of the anus, as well as of the urethra and neck of the bladder; the abrupt and instantaneous retraction of the testicles towards the inguinal ring; and, finally, vomiting, eructations and hiccoughs? Constipation itself is partly the result of this irregular contraction of the digestive tube. The transverse and longitudinal fibres of the muscular intestinal coat become painful, no longer with ease direct the excrements towards the anus. When neuralgic pain is felt in the legs and thighs, can these organs be bent, stretched, &c., with facility and strength? Certainly not, even though there is no paralysis of the painful muscles. The fleshy fibres, the contractile coat of the intestine, greatly excited by pain, experience irregular, morbid contractions, which no more serve to accelerate the course of the excrements in the intestine, than the cramp, which seizes the calf of persons affected with sciatic neuralgia, serves for the advancement or any motion of the leg. The bladder, become painful, cannot free itself with its usual facility of its contents; the irregular contractions caused by the pain produce tenesmus, but do not favor the evacuation of the liquid.

Depression of the abdomen is owing to the pain, and irregular, spasmodic contractions of the organs of the abdomen. Tanquerel agrees with Grisolle, that the abdominal muscles, which are not painful, yet contribute to this depression, by applying themselves instinctively and energetically on the viscera, in order to lessen the suffering. In neuralgias of the face and

lower limbs, do not the painful parts, where there are muscles, become hard? are they not contracted? do they not apparently occupy less room, especially at the time of the exacerbations of pain?

In neuralgia of the face, the secretions of the pituitary and ocular membrane are usually altered, diminished, sometimes even dried up. In lead colic, the mucus which lubricates the intestinal mucous membrane, is no longer secreted in sufficient quantity, and its consistency is different; instead of an unctuous, liquid substance, suitable for facilitating the sliding and progression of the excrements, there is formed only a thick, glutinous matter, strongly adhering to the mucous membrane, and which, it may be said, glues the excrements together in the intestine. The hardness of the excrements may also be explained by the want of the intestinal mucous secretion, and by their prolonged retention in the intestinal canal.

Diminution in the urinary secretion is a consequence of pain in the organ performing that function. In all nervous diseases of the intestines, there is a formation of a great quantity of gas. It is a kind of morbid secretion which takes the place of that of the normal state.

Desbois (de Rochefort) attributed jaundice to the contraction of the duodenum, and the ductus communis, which created an obstacle to the evacuation of bile. Tanquerel attributes it, as he thinks, more correctly and less hypothetically, to a temporary perversion of the functions of the liver; a perversion observed so many times in great physical or moral pain, under the influence of which the bile abandons its habitual reservoirs, and mingles with the liquids and solids of the system, communicating to them its coloring principle.

Difficulties in respiration, the sensation of pressure in the præcordial region, &c., are manifest effects of pain and the irregular contraction of the diaphragm and abdominal organs. Lastly, the circulation seems enslaved by pain. Is not the slowness, hardness, and irregularity of the pulse occasioned by a kind of tension or spasmodic contraction, which may attack the arteries, as well as the muscular fibres?

Since lead colic so greatly resembles diseases called *neuralgicæ*, and the functional lesions which characterize it take place in the organs which receive feeling and motion from the great

sympathetic, it may be concluded, that lead colic is neuralgia of the great sympathetic.

According as such or such nervous plexus of the great sympathetic becomes a kind of centre for the lead excitability, whence lines of irritation radiate, such or such a form of colic appears. Thus as the cœliac, mesenteric, hypogastric, or renal plexus, is the seat of neuralgia, epigastric, umbilical, hypogastric, or renal colic will be manifested.

That which proves that the organs are only the abutments of the pain coming from the great sympathetic, is, that where this is light, and even in certain cases where it is violent, there are no functional difficulties in the abdominal organs, corresponding to the point where it manifests itself. If the viscera were directly affected by the lead, when the pain is seated in the point that they occupy, their functions must necessarily be altered. In neuralgiæ of the organs of the life of relation, the primitive seat of the pain is in the nerve, which is distributed to the painful parts, and not in the organ itself, or the skin, muscles, bones, &c. &c.

An objection may perhaps be made to this view of the seat and nature of lead colic, which has just been established. Tanquerel supposes that the great sympathetic gives feeling and motion to the abdominal organs; but many physiologists refuse to allow this double property to the nervous ganglionic system. Tanquerel agrees in general with Bichat, Brachet, Andral, Jolly, &c., that the trisplanchnic is the centre of action for the organs of nutritive life; as the brain and spinal marrow are for the organs of the life of relation.

If some day, (which is very improbable,) nervous fibres should be discovered coming from another source than the ganglionic system, which should convey sensibility and motion to the organs of the abdomen, then *there* should be placed the seat of colic. Till this discovery is made, no other seat can be assigned to this affection, than that which has been above indicated.

Neuralgia of the great sympathetic, produced by the action of lead on the nervous system, must not be classed with ordinary neuralgiæ. It deserves a place by itself in the nosological chart; for its cause gives an expression to its physiognomy, different from that of common neuralgia.

The study of the precise seat and nature of lead colic, has

engaged the attention of numerous physicians of ancient and modern times. Tanquerel notices the opinion of other authors on this subject, to compare it with his own.

Tanquerel's opinion of the seat and nature of lead colic coincides with that of most modern observers; thus Andral, Grisolle, Ranque, &c., place the seat of colic in the great sympathetic, and also think it is of a neuralgic nature. However, they add that the spinal prolongation is concerned in this affection. But in pure, simple lead colic, no morbid phenomena exist, which indicate a lesion of the nervous, spinal system. It is only in cases where it coincides with paralysis, or neuralgic pains in the limbs, also produced by lead, that this double lesion of the great sympathetic and the spinal marrow is evident. It will be proved, that lead paralysis and arthralgy are not the forced companions of lead colic; they are diseases distinct from, and independent of, the latter.

It must then be admitted, that the trisplanchnic and spinal cord feel, in a certain way, the poisonous effects of lead; but these effects are distinct from each other, and are not produced by irradiation, or by sympathy. Thus colic has its seat only in the great sympathetic, and nowhere else.

CHAPTER XIV.

TREATMENT.

THERE are few diseases, for which so many and so varied medicines have been used, as for lead colic. It would be difficult to cite a single important substance in the materia medica, which has not been prescribed in this disease, and yet, all these therapeutic agents, often possessing contrary properties, number some cures. The origin of these cures, obtained by such different methods, will soon be pointed out.

One of the principal causes for the infinite number of medicines used in lead colic, is the different and numerous opinions with regard to its nature and seat. It has been not only wished to cure this affection, but to know how and why it was cured; hence the numerous therapeutical experiments.

Authors, who recommend one kind of treatment in lead colic, always say that it cures oftener, quicker, and more surely than all other medicines, and that it is a certain protection from the development of other forms of lead diseases. They also, in general, take care to show, that failures and difficulties arise from the administration of methods different from theirs. Some, especially modern authors, report observations to support what they say; others are content with mere affirmation.

To appreciate, according to their just value, the assertions made, and facts reported, to prove the superiority of such or such a medicine in lead colic, all these medicines must be submitted to the test of experience. Tanquerel has tried, or seen tried, nearly all the medicines which have been so much recommended for the treatment of lead colic. These experiments were made on a large scale. He has not been able to try each medicine the same number of times, for when one had been discovered to be superior, it seemed inhuman to experiment with other prescriptions, which experience had proved to be powerless.

The effects of each medicine were noted, hour by hour, and day by day, with the most scrupulous exactness, and without any preconceived opinion. He endeavored to avoid all illusion, and always thought, especially in therapeutics, the maxim *post hoc, ergo propter hoc*, should be avoided.

To judge of the influence of different medicines, the progress of the disease, if left to its own course, and only terminated by the unaided efforts of nature, ought first to be observed. When this examination has been made, the positive influence of the treatment on the issue of lead colic can be ascertained.

The first requisite for understanding this influence, is to observe with extreme care the progress of the different symptoms of the disease. Thus it is necessary to be certain if, on the day when the medicine was administered, there was not already, before this prescription, the commencement of amelioration, if this latter did not manifest itself before the physiological effect of the medicine could have taken place, and finally, if improvement followed, or not, the physiological action of the medicine. It is also necessary to observe at what period of the disease, the remedies are administered, whether at the commencement, the middle, or one or two days before its termination. It is also necessary to know whether the patient has already tried several modes of treatment; and if, from the daily use of the same

therapeutical method, there is from day to day considerable amelioration, each day decided, or if the improvement is slow, step by step. Finally, to appreciate the superiority of one kind of treatment in lead colic, it is necessary to examine whether relief is more decided and permanent, than by other methods, whether the duration of the disease and convalescence are much shorter, and whether relapses are less frequent, and other forms of lead disease supervene less often.

It is also important, to note the intensity and different forms of colic, the infinite variations that individual and external circumstances impress on this malady, whether it renders the cure more easy or difficult. Tanquerel studied each medicine in analogous circumstances, in regard to the intensity, form, and complication of the disease.

Whatever medicine is used, it should be used alone; for if it is associated with other remedies, whose action is different, it is impossible to know to which to attribute the cure.

The experiments made by Tanquerel to obtain positive knowledge, in regard to the influence of the different treatments used in lead colic, having been made in the circumstances just named, and on a great scale, may be regarded as the most certain expression of the truth. The greatest precautions were taken to avoid error. All that is described was *seen*, and *well seen*, by Tanquerel himself, and not by the *nurse*, or *patient*, only. The physicians of the "Charity" and a great many pupils witnessed these facts.

If other observers have not arrived at the same results, it is because they have witnessed so few cases of lead colic, treated in analogous circumstances by different means, and rendering it impossible for them to appreciate all the influences of such or such a medicine, which may contribute to its more or less successful issue.

LEAD COLIC LEFT TO ITS OWN COURSE.

Thirty-one of the patients, eight of whom were attacked with violent, thirteen with moderate, and ten with light colic, were not submitted to any treatment, but all were put on the diet and the use of ptisans, common at the hospital.

Two patients attacked with violent colic recovered, one the eighth, the other the eleventh day after their entrance into the

"Charity." Only one was cured spontaneously after the third day.

Five other individuals attacked with violent colic, after the twelfth day, were subjected to treatment by drastic purgatives, and were cured in a few days.

Six patients, who suffered moderately, were cured after four, seven, eight, nine, eleven, thirteen days' repose at the hospital. Seven were tormented with colic for twelve days, without experiencing very marked or permanent relief. Then more or less active treatment produced a cessation of all the symptoms, in four or five days.

Six patients, whose symptoms were light, recovered eight or twelve days after entering the hospital. Only one recovered the second day. Three, after ten or thirteen days of continual suffering, were treated with different medicines, when the symptoms of colic rapidly ceased. Three of these sixteen cured patients experienced relapses before leaving the hospital. Paralysis appeared three times, encephalopathy twice in these thirty-one individuals, during, or in consequence of colic.

All these patients had suffered for one or more days before entering the "Charity," as is the case with most of those received into hospitals. After twelve days, when the symptoms, left to their course, did not disappear, and seemed unyielding, more or less active medicines were prescribed. The cure must evidently be attributed to the latter.

CHEMICAL TREATMENT.

Hydrosulphuric Lemonade.

Chevallier and Rayer, relying on the well known laws of chemical decompositions, have proposed, in lead colic, the use of hydrosulphuric acid, (sulphuretted hydrogen,) and the natural and factitious mineral waters which contain it, such as the waters of Baréges and Enghien. The sulphuret of lead, which those waters are supposed to form with the lead particles, is without injurious action on the system. The medicine is prepared by taking five grains of sulphuret of potash, and dissolving it in a quart of water; one bottle is administered daily.

Rayer, after some trials of this medicine, quickly perceived that this theoretical treatment did not correspond in practice with

what chemistry made him hope would occur; consequently he abandoned this therapeutic method, which he now regards as entirely inefficacious.

Lalouette, before the above authors, had already said that great relief could be given by the use of sulphuret of potash in the treatment of lead colic, as well as of the mineral waters of Baréges, Bonnes, &c.

Sulphuric Lemonade.

Mosley, and after him, Gendrin, have recommended the use of sulphuric lemonade in lead colic.*

The object in administering sulphuric lemonade, is to transform the lead preparations in the system into sulphate of lead, which is insoluble, and consequently without deleterious action.

Gendrin states that he cured twelve patients in three or four days by this sulphuric lemonade, which, according to his account, constantly diminishes the pains on the second day, and very frequently even on the first, so as to arrest the development of the disease, and in some cases permit the laborers to continue their work. He generally administers two scruples of acid in one or two pints of water, sweetened, and not contained in metallic vessels. (*Trans. Méd.* t. vii. 1832.) Since that period, in a communication to Chomel and Blache, Gendrin says that he has used sulphuric lemonade with such success, that more than three hundred patients have been cured by its administration. (*Dict. de Méd.* 2^e edit. t. viii. 1834.)

Tanquerel, preferring truth before all else, regrets being obliged to contradict the assertions of Gendrin. The medical public ought to know the truth. In the manufactory of white lead at Clichy, which Gendrin appears sometimes to have visited, he has not once been able, by the use of sulphuric lemonade, to arrest the progress of the disease; he has never seen the use of this medicine permit the workmen to continue their labors when they were attacked by pain. This statement, contrary to the opinion of Gendrin, has been confirmed by the overseers and workmen at Clichy, also by the patients of the "Charity" who came from that establishment.

* It is to be observed that Gendrin, in a sharp discussion between Tanquerel and himself, states that he gave Mosley the first intimation of the effect of sulphuric lemonade. See Appendix.—S. L. D.

How could Gendrin cure more than three hundred patients with sulphuric lemonade? It would be necessary that the Cochin Hospital, of which Gendrin was the physician, should have received this number of patients from 1832 to 1834. But the registers of the Cochin Hospital, carefully examined, show that only seventy-six patients coming from Clichy with lead colic were admitted to this establishment from 1832 to 1834. The "Charity" receives as many patients from Clichy as the Cochin, whose lead diseased patients, with the exception of a few painters, &c., come only from the white lead works at Clichy.

Even supposing that half at least of the patients treated by Gendrin were not inscribed on the registers *as attacked with lead colic*, it must be allowed that the probable number of one hundred and fifty-two patients is very different from three hundred. Hence it must be concluded that Gendrin has not "cured more than three hundred patients" by the use of sulphuric lemonade.*

Desirous of verifying the assertion of Gendrin concerning the efficacy of lemonade, Andral, Dalmas, and Sandras, at Tanquerel's request, administered this medicine at the "Charity" to some of their patients.

Fifty three individuals, sixteen of whom were attacked with violent, nineteen with moderate, and eighteen with light colic, were treated in the manner recommended by Gendrin.

In two cases the violent colic ceased after two or three days' treatment. Fourteen other cases of violent colic persisted, or made progress for six or eight days; in two patients convulsions appeared at this time; then the treatment was changed, and by the administration of drastic purgatives the lead symptoms disappeared in from two to five days; three of these patients were cured, one after nine, the other after ten, and the third after twelve days' treatment. In nine cases, the state of the patients becoming apparently worse, after twelve or fifteen days' treatment, the physicians could not conscientiously continue the use of sulphuric lemonade; colic ceased in from one to five days

* Gendrin shows, (*Ann. d' Hygiene*, t. xxvi.) that no such record or "registers of the Cochin" ever existed. Tanquerel afterwards reduced his number from 76 to 52. Adelon and Chevallier, in their statistics of lead patients in the Cochin Hospital, report for 1833, 61 cases. (*Ann. d' Hyg.* t. xix.) All the remarks of Tanquerel on this subject are to be received with caution. See Appendix. — S. L. D.

from the time when energetic drastic purgatives were administered.

In nineteen cases of moderate colic, ten were cured after eight days' treatment, the usual time; eight not progressing towards recovery at the same period, were treated in the manner usually employed at the "Charity," or by croton oil, and were then cured in from two to four days; in the nineteenth, there was a relapse after three days of apparent cure, and paralysis of the wrist and fingers.

Finally, in the eighteen cases of light colic, twelve were perfectly cured in the usual time, seven days and a half after commencing the use of sulphuric lemonade. In one of them, colic lasted seventeen days; in two others, paralysis of the upper limbs supervened. Three experienced relapses.

This medicine was not tried again, from fear of the development of diseases of the brain and spinal marrow; and also because it was painful to see the patients suffering so long, when they could be cured in a few days by other treatment. Besides, the number of experiments is sufficient to prove the influence of this medicine.

If the cases of colic treated with sulphuric lemonade are compared with those where no treatment was used, but little difference will be seen in the results. Tanquerel agrees with a great many physicians at the hospitals, who have tried sulphuric lemonade, that this medicine does not succeed. Bally, Piorry, and Grisolle, tried sulphuric lemonade four times in cases of intense colic, without obtaining the slightest amelioration. In one patient, cerebral accidents appeared after this fruitless trial. These four patients were subjected to the purgative methods, &c., and recovered in five, six, or seven days. Thus, Tanquerel considers the use of sulphuric lemonade in lead colic as a fallacious method, which has scarcely any influence on the progress of the disease.

Alum. — Supersulphate of alumina and potash (alum) has been recommended in lead colic by Richter, Percival, Chapman, Lindt, Michaelis, Grashuys, Mosley, Adair, Schmidtman, &c. Kapeler states, that given in a dose of from one to three drachms per day, in a demulcent draught, sulphate of alumina always cured colic, however intense it was. Montanceix says, that the cure is complete and permanent in six or seven days, and generally without relapse. He also proposes, on account

of the efficacy of this method, to call it the treatment of the *Hospital of Saint Anthony*, in distinction from that of the "Charity." (*Arch. génér. de Méd.* t. xviii.)

Gendrin affirms, that in fifty-eight patients attacked with well marked colic, several of whom had resisted other means of treatment, he has not *once* seen alum prove ineffectual, or produce the least accident in the digestive organs. By administering a dose of a drachm or a drachm and a half at the commencement of the disease, he has arrested colic, in from ten to fifteen hours, in twenty-three persons, and ten were not interrupted in their usual work of painting. But he observes, that when the dose is increased to two drachms, or two and a half, taken in twenty-four hours, accidents sometimes occur.

Tanquerel, eight times had occasion to observe the effects of alum in lead colic; he prescribed it according to Kapeler's method. The pains were intense in two patients, moderate in five, and light in one. One of the cases of violent lead colic was not at all modified by the use of this treatment for thirteen days; the usual method of the "Charity" was then resorted to, which caused a cessation of the pain. The other case of violent colic was cured in eight days, during which time were administered alum and *purgative clysters*. Of the five cases of moderate colic, three were cured in twelve days; the two others not being relieved by alum, prescribed for twelve days, were then treated by croton oil, and with rapid success. Lastly, the case of light colic ceased in nine days.

The advocates of alum may perhaps object that these observations were not sufficiently numerous. Tanquerel allows this; but he replies that the failures which attended the administration of this medicine, in eight cases of colic, ought to prevent such experiments being made in a *very painful* disease, which is almost always sure of being cured by other medicines. Besides, Tanquerel has never met with so many failures in colic, one after another it may be said, when any treatment was employed whose salutary influence on the disease was real. In nearly all the cases of cure, obtained by the aid of alum, purgative clysters were prescribed at the same time. Is it not then as logical to attribute the success to these last as to the use of alum?*

* Alum still has its advocates. Dr. Hoffman (*Medicin. Zeitung*) quoted in the Chemist, 1845, highly extols the use of alum combined with opium. — S. L. D.

Mercury.—Clark, Gardane, Berger, Hunter, &c., recommended mercury to cure lead colic. These authors imagined that this metal dissolved the lead preparations which were disseminated in the intestine. The ancient *Journal Général de Médecine, Chirurgie et Pharmacie*, of January, 1808, gives, from the *Gazette de Saltzebourg*, a notice of fifty persons successfully treated for lead colic, by a mixture of mercury and opium.

Lead.—Lead itself has been administered. Harlan says he observed good effects from a mixture of three grains of acetate of lead, one grain of opium, and five grains of calomel, divided into three doses. But it is probable that these two last medicines had as large a share as the acetate of lead in his success, if he really had any.

Nux Vomica.

Nux vomica has been highly recommended by Serres in lead colic. Tanquerel has examined this assertion by experiment.

At Tanquerel's request, *nux vomica* was prescribed to fourteen patients, in the "Charity."

The following results were obtained.

This medicine was prescribed as a clyster, in a dose of thirty drops of the alcoholic tincture, in six ounces of decoction of mallows. One or two clysters were administered according to the intensity of the symptoms.

In four cases of violent colic, the medicine was administered for five days without amelioration or evacuation; the clysters only were returned. The day following, the pains and other symptoms, in two of the patients, diminished and completely ceased; but from the tenth to the fourteenth day, the symptoms having reappeared in one of them, with great intensity, the use of croton oil produced a complete cessation of all the symptoms in from three to six days. The two other patients experiencing no amelioration from the *nux vomica*, from the seventh to the ninth day, drastic purgatives were prescribed, and the colic rapidly ceased.

In five patients treated with *nux vomica*, the colic was of middling intensity. There were no purgative effects after the return of the clysters. One or two days after entering the hospital, three patients began to be relieved; the following day evacuations took place, but difficult and not abundant; they

were finally cured in the usual time, the eighth day. Of the other two patients, one had a relapse of colic, accompanied by paralysis of the wrists, the twelfth day, when the cure was considered nearly complete.

Finally, the fifth patient, on the fourteenth day of treatment, having been alternately better and worse, without settled amelioration, when treated by croton oil, all the symptoms ceased the third day of this new treatment.

Of five persons attacked with light colic, and treated by *nux vomica*, none were cured before the sixth day. At this period, and at night only, some evacuations took place. One experienced relapses, and more efficacious means were obliged to be used.

The facts speak for themselves; they need no comment to prove that *nux vomica* has no influence, or at least, a very slight one on the course of lead colic, and that this medicine, in these circumstances, had no purgative effect.

ANTIPHLOGISTIC METHOD.

The use of antiphlogistics can be traced to a very remote period. Dehaen was one of the first and most ardent advocates of this method. After him Hoffman, Gaubius, Astruc, Bordeu, Tronchin, Tissot, Bosquillon, &c., have recommended this method. In modern times, Renaudin and his pupils Canuet, Thomas, and Palais have extolled this kind of treatment.

Grisolle has given the history of three patients, showing all the symptoms of intense lead colic, who were treated by Renaudin, by the application of leeches several different times; and by the simultaneous or successive administration of narcotic preparations, the cure was completed in the usual time of eight days.

In all the cases of colic reported by different observers, that were treated by the antiphlogistic method, laxatives, purgatives, and opiates were nearly always used at the same time. But is it not as correct to attribute the cure to these last medicines, as to the emollient and antiphlogistic method? Thus Grisolle says, that in the three cases observed by him, the antiphlogistic method was tried only one day, for afterwards narcotic preparations were used.

To appreciate the just value of the antiphlogistic method truly,

necessarily, general or local blood-letting, cataplasms, emollient clysters, baths, and diluting drink should be used.

Tanquerel has observed the influence of the pure antiphlogistic method in forty-eight cases of lead colic not complicated. These patients were bled once, rarely twice; two or three applications of leeches, to the number of twenty or thirty, or the cupping glass were prescribed. At the same time simple baths, emollient clysters, and cataplasms were used, and strict diet was maintained.

Four patients attacked with violent colic were cured after three, eight, nine and twelve days' treatment. In seven other cases of violent colic, the pain and other symptoms were momentarily calmed by each general or local blood-letting. But in a few hours, or the next day, the disease returned with the same intensity. In one of these patients after six days' treatment, the affection seemed to have completely disappeared, when suddenly it returned more violently than ever. These seven patients, after having suffered from twelve to fifteen days, were subjected to purgative treatment, and were then cured in a very few days.

Eighteen patients affected with colic of middling intensity were treated by antiphlogistics, thirteen of whom were cured; three in two, four in seven, two in eight, two in nine, two in ten, three in eleven, and one in thirteen days' treatment. One had a relapse the fifteenth day; and three were not free from their pain after twelve or fifteen days' trial; subjected then to energetic purgative treatment, the symptoms of colic disappeared in four or five days.

Nineteen persons who had light colic were all cured, except seven, in a variable space of time, whose mean duration was seven days; two had relapses. The cases of lead disease which resisted antiphlogistics, yielded to purgatives.

Of these forty-eight patients, four were attacked with lead paralysis, and two with encephalopathy, during the use of antiphlogistics.

If these patients are compared with those who were treated with sulphuric lemonade, alum, and nux vomica, it will be seen that antiphlogistics seldom abridge the duration of colic more sensibly than other treatment; that during its employment there are not more patients cured, and the number of relapses and attacks of cerebro-spinal disease, is nearly as great.

Eighty patients, before entering the hospital, had been treated

by antiphlogistics, their disease having been taken by their physician for an inflammation; some practitioners who had taken care of these workmen acknowledged that they knew no other treatment to oppose to this disease. Sixty-five of these patients suffered more at their entrance to the "Charity," than before being treated in this way; six were relieved, and eighteen were in the same state.

Antiphlogistic treatment then seems to have no well marked influence on the course of colic. It is useful when colic is complicated with inflammation. But to be sure that this complication exists, there should be a union of local and general symptoms, which leaves no room for doubt.

Then it is very necessary to employ the antiphlogistic method first to remove the inflammatory symptoms, before the lead disease can be successfully combatted. Thus the febrile movement, redness, and dryness of the tongue, lively sensibility of the abdomen to pressure, even in the exacerbations, increase of the symptoms by the use of drastic purgatives or even their inefficacy, are the only circumstances which positively require the use of antiphlogistic treatment.

Sometimes these phenomena which denote phlegmasic pains do not exist at the commencement of the disease, but appear later after the use of irritants, then the administration of these medicines must be discontinued, and leeches or bleeding resorted to; later it may be safe to resume the ordinary treatment.

Some physicians still think, contrary to what Tanquerel has seen, that the state of the pulse in lead colic is always a guide to indicate the treatment, and recommend general bleeding, &c., even though the pulse is slow, provided it show unusual strength and hardness. In these circumstances, Tanquerel's experience has proved that bleeding is *always* useless, and consequently injurious. Treatment by drastic purgatives succeeded wonderfully. Lherminier, gifted with great clinical skill, has permitted Tanquerel several times to observe this fact, in his practice.

Diarrhœa, unless it is united to continual febrile movement, or to local phenomena, which indicate phlegmasic pain, does not require the use of the antiphlogistic method. This symptom disappears like pain, in cases of lead colic, exempt from complication, by the use of the vomipurgative method.

In thirty-eight cases of lead colic complicated with phlegmasiæ of the digestive tube or other organs, antiphlogistics sometimes

removed the complications, and then drastic purgatives were employed with efficacy, where at first they did not check the progress of the colic.

CALMING METHOD.

The treatment of lead colic by narcotics has been recommended by physicians of great authority. Citois, Tronchin, Dehaen, Stoll, Payen, Hillary, Romans, Luzuriaga, Adair, Volff, Bourdois Bricheteau, Bouvier, Martin Solon, &c., have used this medication, and have published their success.

Stoll has been one of the greatest and most powerful panegyrists of the administration of opium in lead colic. The illustrious physician of Vienna did not use this medicine according to theoretical views. The first time he tried it, was with reluctance; for he thought that opium would increase the already existing constipation, &c. "Touched," he says, "by the cries of a patient, who for seven days had not evacuated, notwithstanding all the means employed to effect this, and who from time to time vomited amid the most severe pains, I administered opium to him. Soon after, the abdomen relaxed spontaneously and he evacuated a great quantity of matter, then the pains and vomiting ceased." After that, Stoll used opium extensively, and his cures were *very happy, prompt, lasting and numerous*.

Generally, Stoll prescribed to each patient in the twenty-four hours, a mixture composed of ten grains of opium, six ounces of camomile flowers, a drachm and a half of extract, and an ounce and a half of syrup of the same flowers. The patient took one sixth part of this every four hours, and the use of it was often continued for several days.

One of his patients who had vomited exceedingly, took with success thirteen grains of opium in one night. "Opium," adds this illustrious physician, "cures lead colic, when its use is persevered in. This I have proved by numerous observations; but it must be administered in proportion to the degree of the disease, and continued long enough. I did not discontinue the use of it, although the patient was absolutely free from pain. It is necessary that the pulse should have regained its natural suppleness, experience having taught me, that, when this sign is wanting, the character of the poison is not entirely destroyed."

It is to be regretted, that Stoll did not publish, as he intended,

an extensive work on lead colic, where he might have related more in detail all the cases which he had treated by opiates. This omission is the more to be regretted, because Stoll sometimes appears to have erroneously attributed his success in curing lead colic, to opium *only*. In short, he employed two methods at the same time, the *calming* and the *evacuating*. The last was composed of purgatives and emetics. This composing method succeeded completely, and had not the disadvantages of both employed separately. From this testimony of Stoll himself, part of his success is to be attributed to the *evacuating* method.

TREATMENT OF RANQUE.

Ranque, physician at the Hotel-Dieu of Orleans, proposed to treat lead colic by narcotic and revulsive medicines, employed according to specific forms. The two following ways compose the method.

The first consists in the application of plasters to the belly and loins, called *abdominal* and *lumbar epithems*, for they cover these regions from the pit of the stomach to the pubis, and the loins to the sacrum. These epithems were composed of dyachylon and camphor, opium, sulphur, tartrate of antimony. A second part of the treatment of Ranque, consisted in the use of friction, with liniment composed of sulphur and extract of belladonna, and the internal administration of ethereal tincture of this plant, together with clysters of the same with olive oil and decoction of flax-seed.

The epithems were intended to act speedily upon the nervous expansion under the epidermis of the parts to which they were applied. They were either sedative or sedative and revulsive. The potion and clyster were intended to remove constriction in the rectum.

In eighty-four cases of lead colic, twenty-two light, thirty moderate, and thirty-two violent, Tanquerel observed the effects of opium or hydrochlorate of morphine, administered alone without being associated with purgatives, emetics or emollients, &c.

Opium was given to thirty-eight patients, in various doses, from two to ten grains, according to the intensity and obstinacy of the symptoms. Each grain was divided into several pills, and administered day and night, at intervals as equal as possible.

Hydrochlorate of morphine, taken by forty-six patients, was administered in from one to seven grains, equally divided into several pills, and given in the same time as the opium. The attendants were careful that these pills should be taken regularly.

The symptoms in the cases of light colic disappeared in five or six days. When the affection was of medium intensity, it ceased in six or seven days, and finally disappeared in the mean time, after eight or ten days' treatment. There were five relapses, four cases of paralysis during the course or at the termination of colic, and encephalopathy appeared three times.

Twenty-five cases of colic, six of which were light, ten moderate, and nine very violent, resisted this medicine for twelve or fourteen days. The use of purgatives overcame the symptoms. But in eight cases of violent and two of light colic, which were not cured by the repeated use of vomipurgatives, the administration of opiates caused the colic to cease in a few days.

Treatment by opiates evidently has a salutary and more marked influence on colic, than the other medicines which have been previously noticed. Finally, it very often abridges the disease by some days, renders relapses, paralysis and encephalopathy a little less frequent.

The enthusiastic partisans of narcotics may perhaps consider this result, with regard to the efficacy of this method as too little in harmony with their observations. But if these medicines are administered alone, and every necessary precaution taken to appreciate correctly the influence of this treatment, and always allow their proper share to repose, diet, and the curative efforts of nature, Tanquerel's opinion would soon be considered correct.

Andral prescribed four grains of opium to a patient attacked with the most violent lead colic. Tanquerel was not a little surprised, the next day, to find him entirely cured. After a separate and careful investigation, as to the period when the symptoms began to diminish, Tanquerel and Andral found that there was very decided amelioration two hours before taking the first opium pill, and that the improvement would have increased, even if other pills had been administered.

The opium was discontinued, and yet the following day there was no relapse. If this fact had been observed by an enthusiastic partisan of opiates, he would not have failed to ascribe the cure to the medicine. Several students who accompanied Andral

in his visit, were amazed and already sounded the praises of this powerful remedy, before the period of the diminution of the symptoms had been discovered. Tanquerel has seen no difference in the influence of hydrochlorate of morphine and opium.

When the cure results from the administration of opiates, the following is what generally happens : after two or three days' use of these medicines, the patient is slightly relieved, although he neither sleeps or evacuates. The following days amelioration continues in a perceptible manner ; but sometimes the pain suddenly reappears with all its energy, the amelioration takes place again, and the cure comes in the same time as before. In a few cases the cure takes place very rapidly ; in two or three days the symptoms amend a few hours after the administration of a great quantity of opium.

The cure is first announced by a very prompt cessation of pain, followed a day or two later by evacuation. It is astonishing to see with what facility the feces are evacuated.

Opiates given in large doses to individuals attacked with lead colic do not produce as easily as in other diseases the symptoms of narcotism, as intoxication, sleepiness, agitation, gapings, heaviness of the head, dreams, tenesmus, sweats with itching, vomiting, constipation, &c. ; therefore very large doses can be given in this disease without danger.

It is difficult to treat by so painful and slow a method as that of Ranque, the patients who come to the Hospital of Charity ; for they, knowing that cures are performed there rapidly, and by other medicines less painful, do not wish to endure the suffering of this peculiar method, and this has prevented Tanquerel from verifying the facts advanced by the physician of Orleans.

REVULSIVE METHOD.

Vesicatories applied on the abdomen or thighs have been recommended to cure lead colic.

Dupuytren, having cured in a painter by a large vesicatory, a dyspnœa, which he attributed to the effects of lead, thought proper, after this single case, to recommend this treatment for all lead colic.

In one case of colic, violent, and for six weeks obstinate under all kinds of treatment, the application of a large vesicatory on the abdomen was followed by the cure of the abdominal affection.

This method was tried on several others without any legitimate success.

PURGATIVE METHOD.

Lead colic treated by purgatives experiences different modifications in its progress, according to the manner in which these medicines are administered, by the anus or mouth; also according to the intensity of their physiological and pathological action. Most of the ancients who have spoken of colic caused by lead medicines, recommend for treatment drastics and emetics.

The idea of metallic particles lodged in the intestines, the cause of colic, as well as constipation, would naturally suggest the thought of emetico-cathartic treatment. Celsus recommends that those who have swallowed white lead should be made to vomit; Dioscorides, who seems to have known more of this colic than Celsus did, mentions, as a curative method, vomiting and purging; Paul of Ægina, and Ætius, are of the opinion of the preceding writers. Avicenna recommends emetics, purgatives, hot diuretics.

In following centuries most physicians, forgetting the advice, vague and inaccurate it is true, bequeathed to them by former authors, as to the treatment of lead colic, treated it according to the prevailing medical ideas of the time.

Treatment of the "Charity."

In 1602 some Italian monks, sent by Mary de Medicis to manage the Hospital of Charity at Paris, founded by her, brought several recipes from their own country, one of which they used in certain grave diseases; it was called *macaroni*. This remedy was composed of one part of glass of antimony and two parts of sugar, very carefully mixed and powdered very fine; they gave it in a dose of one scruple three or four days in succession. These monks used this powerful medicine successfully in lead colic.

Later, when physicians succeeded monks in taking care of the patients of the "Charity," the treatment which bears the name of this hospital continued by custom to be used in lead colic.

The success which attended this treatment, directed successively at the Hospital of Charity, by the physicians Delorme,

Hardouin de St. Jacques, Colot, and Imbert, extended in every direction, even among the common people; hence the "Charity" became the general infirmary where all persons attacked with lead colic resorted. This ancient renown still causes a great many painters, white lead workers, &c. to resort there, though few of the physicians any longer prescribe this medicine. As in the time of Borden, the public still think that there is used at the "Charity" a peculiar remedy for lead colic, an arcanum, in short, an infallible method unknown elsewhere. It would be a great mistake to think that the treatment at the "Charity" was originally what it is now. It has undergone infinite transformations, which have served sometimes to multiply, sometimes to diminish its success.

Macaroni is only the germ of the treatment now used at the "Charity." But even at that period, when it consisted substantially in purgatives and emetics, it was only a remembrance of the treatment of the ancients. It is difficult to assign the precise period when it began to be reduced to formulas nearly similar to those used now. The treatment of the "Charity," as administered now, consists in an assemblage of numerous substances endowed with different properties. It is as follows:

First day, cassia water; simple sudorific ptisan, purgative clyster in the morning, anodyne clyster in the evening, theriaca one ounce, opium 1 gr.

Second day, Blessed water, (*eau bénite*), simple sudorific ptisan, purgative, and anodyne clysters, opiates as before.

Third day, laxative sudorific ptisan, two glasses; simple sudorific ptisan, clysters and opiates as before.

Fourth day, purgative potion in the morning, simple sudorific ptisan, opiates as usual.

Fifth day, repeat the treatment of the third day.

Sixth day, repeat the treatment of the fourth. The seventh day continue the treatment of the fifth.

THE FORMULÆ OF THE ABOVE PRESCRIPTIONS.

Simple sudorific ptisan.

R. Common decoction of guaiacum, 1 quart.

Laxative sudorific ptisan.

R. Infusion of senna and decoct. guiac aa. . . . 1 quart.

Cassia water.

R. Decoction of tamarinds 1 quart, (2½ oz. tamarinds.) 1 quart.

Glass of antimony, 2½ grs.

Blessed water.

R̄. Glass of antimony, 4 grs.

Purgative potion.

R̄. Infusion of senna, 4 oz.
 Electuary of diaphœnix, 1 oz.
 Syrup of buckthorn, 1 oz.
 Jalap, 20 grs.

Purgative or painters' clyster.

R̄. Infusion of senna, 1 pint.
 Sulph. soda, ½ oz.
 Electuary of senna, 1 oz.
 Jalap, 20 grs.

Anodyne clyster.

R̄. Nut oil, (*huile de noix.*) 4 oz.
 Red wine, 10 oz.

Bolus theriacal.

R̄. Theriaca, 4 drachms.
 Extract of opium, 1 gr.*

Thus the treatment of the "Charity" is composed of drastic purgatives, opiates and sudorifics.

When the medicines of these different formulæ create too much disgust in the patients, or cause vomiting, in this case only those medicines should be administered which do not produce vomiting, and can be swallowed without too much disgust.

During the treatment of the "Charity," severe diet is prescribed for the two or three first days. The fourth or fifth day, a little broth is allowed. Afterwards the food is gradually increased.

Such is the famous treatment of the "Charity," the reputation of which has been transmitted from age to age until now; and yet, few physicians at the present day employ it in its original purity. Generally each practitioner uses one or more medicines, by which he hopes to obtain the same physiological and therapeutical results. Even now, if the physician of a ward at the Hospital of Charity prescribes this treatment in all its purity, he must minutely charge the attendants to administer all the clysters, ptisans, potions, &c. Without this

* It will be noticed that several articles in the above, though retaining a place in the French codex, are expunged from modern dispensatories. Dates are the principal ingredient in Elect. Diaphœnix, and Theriaca depends on the watery extract of opium. — S. L. D.

precaution, parts of the treatment of the "Charity" will generally be neglected.

This treatment has been extolled with blind enthusiasm. Its partisans have made it a *sine qua non* for curing colic. *Facts* reported in its favor will now be examined.

For nearly two centuries and a half, the monks and physicians of the "Charity" performed wonders with the *macaroni* or its substitute, without these extraordinary cures being published in any collection. Tradition alone preserved them. At length Dubois (1751) wished to extend the use of such a therapeutical method, by publishing his famous thesis. But instead of resting his assertions on facts drawn from his clinical practice, he endeavors to support them by a crowd of reasons drawn from the laws of corpuscular physics; and yet, this work caused the treatment of the "Charity" to triumph, which has since been generally regarded as the most active and most speedy remedy, and supported by the greatest number of facts. Dubois speaks of this famous treatment in the following enthusiastic terms: *Tam facile, tam cito, ægrum ad sanitatem reduximus. Gaudet, valet, surgit, sanatus est æger! Tota curatio quatrIdui est. . . Non secure disseramus.*

Since Dubois, most of the physicians at the "Charity" who have written on lead colic, have lauded the effects of this treatment. Only two have reported observations in support of what they say, Combalusier and Merat. Combalusier administered this method to ten patients, whose history he has related. Eight were cured in from six to eight days; two succumbed.

Merat, in his work, relates the history of nineteen cases of colic combatted by this mode of treatment.

Twelve patients attacked with acute lead colic were cured after three to thirteen days' treatment. One died from an attack of lead encephalopathy, another was attacked with paralysis.

Six patients attacked with chronic lead colic were cured after four, eight, ten, eleven, twenty, and twenty-six days' treatment.

Most of the modern physicians of the "Charity" speak of the brilliant success they obtained by this treatment. Bayle, Laennec, Chomel, Rullier, &c., have, in their books or in other works, announced, but without formulas, the success that they obtained.

The treatment of the "Charity" has been depreciated as much as it has been praised. Among the monks of this hos-

pital, there was one named Stanislas, who opposed the *macaroni* treatment, and took great care to make known the sad and fatal consequences of its administration; this gave, at the commencement of the eighteenth century, the first decisive blow to the wonders of macaroni.

Some practitioners have been unwilling to try this mode, from fear that medicines as active as those which are used in it might increase the violent pains of the colic. But in medicine, reason can never be substituted for experience. It ought to be proved that these fears are well grounded; facts should be shown in their support, and the documents presented by other observers so favorable to this method, should be combatted. Although the experience of several centuries has appeared to sanction the superiority of this treatment of the "Charity," Tanquerel wished to verify what has been advanced on this subject.

Tanquerel treated three hundred and forty-five patients according to the method of the "Charity." One hundred and ten were attacked with violent, one hundred and thirty-five with moderate, and one hundred, with light colic; three hundred patients were cured. Colic lasted, counting from the day when the treatment was commenced, the mean time, from six to seven days, nearly all the time that the medicine was used. Of this number, seventeen experienced relapses; twelve were affected with paralysis, and seven with lead encephalopathy.

Among the thirty-seven who were not cured, five succumbed to cerebral or spinal accidents produced by lead; seventeen were attacked with chronic colic, and fifteen with acute colic. These last were cured by other medicines, such as vesicatories, opiates, Sedlitz water, or croton oil.

The two first days that this method is employed, the patient vomits a great many times, but evacuates rarely and with difficulty. The stools are scarcely ever composed of solid matter; generally the clysters are returned just as they were taken. Usually, the patient is but little or not at all relieved, yet in some cases of violent, moderate, or light colic, the affection completely disappears at this period, even without evacuations, in consequence of frequently repeated vomiting.

On the third day, may be observed in some cases, abundant evacuations and marked relief. On the fourth day especially, numerous stools occur, composed in part of scybala; finally, the pain and other symptoms rapidly diminish in a marked manner.

Several times when the treatment of the "Charity" was not commenced till the fourth day, some advantages were shown; the disease was of shorter duration.

The following days, the symptoms of colic finally disappear in an insensible manner. The sixth day often removes, as if by enchantment, the last suffering, but always by purging.

In nearly half the cases, theriaca and opium were not given to the patients; relapses and attacks of other lead diseases, were not more numerous than in persons who had taken the theriacal bolus.

There was not a single case of gastro-enteritis from this treatment, even when the abdomen was sensible to pressure, or when there was an acceleration in the circulation. But when really inflammatory phenomena accompanied colic, the treatment of the "Charity" aggravated the complication, without diminishing the intensity of the neuralgia.

By comparing all the treatments for lead colic that have been mentioned, it is evident that the method of the "Charity" exerts a more positive and happier influence than all the others. It shortens the duration of the affection, and causes it rapidly to disappear, preserves from relapses, and protects, in a certain degree, from other lead diseases, since it removes the poison more quickly from the system. Yet Tanquerel does not say, like Merat, that this is a certain remedy in colic, and never fails when properly administered. The facts that he has witnessed and collected with great exactness, cause him to speak with reserve. He thinks, that *the treatment of the "Charity" is not a certain specific, like mercury and quinine.*

The treatment of the "Charity" appears to Tanquerel to be a complex method, *most efficacious* in lead colic. This opinion, formed after rigorously exact observation and great impartiality, yet gives to this treatment a value, which will make it always one of the best therapeutical methods that science possesses.

How does the treatment of the "Charity" act to cure colic? It appears that originally this method was so violent in its action, that the patients, in consequence of violent vomitings and purgations without number, that the drugs produced, were seized with convulsions, so that four men could not restrain them. "Thus," says Bordeu, "it was a violent specific, but respectable from its antiquity!"

Are not all the discussions on the *modus operandi* of this

treatment of the "Charity" idle? Is it known how quinine acts in intermittent fever? All that is known is, that the method employed at the "Charity" acts by giving a lively shock to all the organs which are the seat of colic. This disturbing method violently changes the condition of all the solids and liquids, and restores them to their normal state, after having, probably, dispersed all the lead, which produced the symptoms.

In preceding years, a great many practitioners have attempted to treat lead colic by means drawn partly from this *famous treatment*, without trying to follow it literally, or, it may be said, servilely. Some, omitting the emetics and purgatives, preserved only the narcotics; others, on the contrary, have only used purgatives, or even emetics. Lead colic treated by opiates has already been noticed.

Purgative Clysters.

In sixteen cases of colic, Tanquerel observed the influence of purgative clysters administered alone. These clysters were composed like that called *painters' purgative*, and one or two given per day. Six persons attacked with light colic, were cured after four days' treatment. Of five patients attacked a little more severely, four were cured in six days, and one was entirely freed from his symptoms, only by the administration by the mouth, of purgative medicines. Five patients attacked with violent colic, were relieved after three or four days' treatment, but complete cessation of the pain was delayed so long, that three were obliged to take croton oil, before the symptoms completely disappeared.

The first clysters do not generally overcome the constipation, or diminish the pain. They are returned as they are taken, and the patients rarely retain them long enough for any efficacious action to take place. Later, after two or three days, evacuations take place, composed in part of hard, dry, black or yellow matter, and but slightly consistent. Even when no alvine evacuations can be obtained, the patients sometimes say they are relieved.

Castor Oil.

Most laxative oils, chiefly that of *ricinus communis*, have been recommended by several practitioners, and especially by

the partisans of the antiphlogistic method. (Grashuis, Barry, Mosley, Fricher, Odier, Romans, Eyerel, Renauldin, &c.)

This gentle purgative, administered in doses of from one to two ounces per day, may cure light lead colic; it then produces scanty evacuations, in consequence of which all the symptoms disappear. But, if the disease is violent, castor oil seldom has any influence upon it, and purgative effects do not take place. In twenty-eight cases of light lead colic, this laxative, administered one or more times, contributed to the cure, which was completed in five days. In twelve cases of moderate lead colic, only eight were cured, and after six days; with the other four, it was necessary to resort to more energetic measures, to effect a complete cure. In four subjects, attacked with violent lead colic, treated by castor oil, only one was cured, and after six days' treatment; it was necessary to use more active means with the three other patients.

Sedlitz Water.

Sedlitz water has the same curative influence as castor oil, on lead colic. Tanquerel met with two cases of intense colic, where this purgative seemed to have the greatest success. In these two patients, the lead colic was very violent, and had lasted for six weeks or two months, though a crowd of medicines had been used, (treatment of the "Charity," croton oil, sulphuric lemonade, leeches, &c. ;) finally, for a change, Sedlitz water was tried; the day following the administration of this medicine, all symptoms of the disease had disappeared. Was the disappearance of the disease, and the administration of the medicine, any thing more than a simple coincidence, a relation of cause and effect? It would not be prudent to affirm this positively, especially as colic sometimes, when left to itself, terminates abruptly.

Croton Oil.

Croton oil, recommended in metallic colics, by Dr. Kinglake, has been very frequently used, of late years, in lead colic. It is now the method usually employed in this malady.

Tanquerel, in his thesis on lead paralysis, in 1833, announced the advantageous effects, that Rayer had obtained, from croton oil in lead colic. In another hospital, Andral had collected

facts about lead colic, fitted to establish the remarkable advantages of this medicine in this disease. (*Thèse de Joret.*)

Tanquerel observed four hundred and sixty cases of lead colic, treated with croton oil. Sometimes this medicine was given alone, or with other purgatives, such as painters' clyster, castor oil; sometimes it was associated with opiates.

In two hundred and ninety cases of colic, this medicine was administered alone, one or more times according to the intensity and tenacity of the symptoms. The days when no croton oil was prescribed, the painters' clyster or castor oil was given; Sedlitz water was administered in eighty-five of these cases.

In eighty other patients, the same day that the croton oil was administered, the patient took a purgative clyster in the evening, as an adjuvant means.

All these three hundred and seventy patients, with the exception of twenty eight, were cured in four or five days, from the time when this medicine was employed. Colic was violent in one hundred and forty-one of these individuals, moderate in one hundred and twenty-three, and light in one hundred and six. It took a little longer time to cure the violent colic than the moderate or light.

The best mode of administering this, is the following: one drop of croton oil, given in a spoonful of ptisan. Croton oil, in the same quantity, taken as a pill, in rob of elder, or mixed with other medicines, acts with much less energy. Why? The disease, generally, disappeared most quickly when the oil was given the greatest number of days in succession. Thus, the cure was most speedy in cases where painters' clyster, castor oil, or Sedlitz water, were not given after one day's administration of croton oil.

It is very often the case, where croton oil is prescribed *only once*, colic diminishes at first from the effect of the drastic purgative; after that, it increases insensibly and *slowly* the succeeding days. But very frequently there is a recrudescence, after three or four days, of very decided amelioration. Drastic purgatives must again be resorted to, to entirely overcome the colic. To obtain very advantageous results, it should be prescribed at least three days in succession, even when the first dose has produced wonders.

No fear need be felt of producing inflammation of the intestinal mucous membrane. Tanquerel has not once seen it. In

three patients, croton oil, instead of producing evacuations, gave rise to symptoms of irritation of the digestive organs, which disappeared the next day by repose and soothing clysters. Patients attacked with lead colic can take, without injurious effects, much more violent, and much larger doses of purgatives, than individuals affected with diseases foreign to lead.

In cases where purgative clysters were prescribed as adjuvant means, the cure was not generally more rapid than when croton oil was administered alone. Yet it sometimes happens that croton oil alone produces no marked effect; clysters provoke its energetic action; then vomiting and numerous evacuations take place, and very decided amelioration is evident. It is then useful to prescribe, in the evening, a purgative clyster, when the oil in the morning has produced no results. In this case, it is still better to prescribe a second drop of oil in the evening, and the physiological and therapeutical effects may be produced by this new administration.

The effects of croton oil usually occur very soon after its introduction into the stomach. Its physiological and therapeutical action usually commences one, two, or three hours after it is taken.

Frequently, very decided amelioration, astonishing to one who has never before witnessed it, takes place the day after the administration of the croton oil. Yet the evacuations are usually half liquid, scanty, and seldom very frequent the first day after the oil is prescribed. In some cases they are completely wanting, and only abundant vomiting takes place. But by the next dose of croton oil numerous stools occur, and the evacuation amounts to a considerable quantity of hard, rounded excrements, (scybalæ.) The colic very often ceases entirely, or almost entirely, the day after this new dose of oil. The third, fourth, or fifth day, colic is entirely cured, if the symptoms have not previously disappeared.

In nearly half the cases, vomiting supervened one or two hours after taking croton oil, and generally produced decided relief; sometimes it happens that croton oil acts only as an emetic, and not as a purgative. Then it sometimes cures; at other times, on the contrary, no success is obtained. In some cases, the patient vomits in a few minutes, or a quarter of an hour, after taking the oil; the medicine being vomited with the other matter, can no longer produce physiological and therapeu-

tical effects. In this case some other medicine should be given. It may be mixed with castor oil, that is, with a less exciting substance, or given in a clyster; the cure will not be so speedy, nevertheless, success will be obtained. When vomiting takes place, it generally precedes evacuation, and when the latter commences the former ceases.

Some patients, without vomiting or alvine evacuation, are nevertheless relieved. It is well, after prescribing croton oil for one or more days in succession, to make use for a few days of purgative clysters, even though the patient does not feel the slightest colic pain. This practice has the advantage of preventing some of the relapses. The effects of croton oil last more than a few hours after taking this medicine. Sometimes the purgative action continues one or two days.

In ninety cases of lead colic, twenty-five of which were violent, thirty-two moderate, and thirty-three light, where opiates were used with croton oil, the results were neither more nor less favorable than the preceding. Seven patients resisted the combined use of these medicines.

In some patients, fatigued with the superpurgations produced by the repeated administration of croton oil, opiates have caused these light symptoms entirely to disappear.

Thus of four hundred and sixty patients, thirty-five were not cured, a proof that this treatment is not *always* successful in lead colic. Seventeen of these persons vomited the oil as soon as it was taken. In some of these patients, entirely refractory to the action of croton oil, this medicine is scarcely swallowed when it occasions great agitation; the patient vomits, experiences a burning sensation the whole length of the œsophagus and in the epigastrium; every time he drinks, the taste of the oil is renewed, and he vomits even the most digestible drinks. In these cases, if the use of croton oil is continued, inflammatory symptoms might perhaps be produced. Fourteen were vigorously purged by this medicine, and yet the colic did not disappear; other energetic medicines were administered to them, which at first had not more marked effects; finally, after a time, varying from fifteen days to three months, the symptoms disappeared during the administration of medicines not generally considered as having very great influence in curing this malady, (Sedlitz water, hydrochlorate of morphine, vesicatories.) Three experienced slightly exciting phenomena in the digestive tube,

and the use of these means was discontinued. Finally, one of these unfortunate sufferers was treated ineffectually with several doses of croton oil, as well as by all other methods; every thing was unavailing, he succumbed, exhausted by the excess of pain.

There were twenty relapses in all these patients. In sixteen cases, paralysis appeared in consequence of colic being treated in this way; encephalopathy occurred in nine cases.

There are some seasons, or medical constitutions, during which the success of croton oil, in removing lead colic, varies. Thus, Tanquerel has observed that in moist and cold weather this medicine acted less advantageously than in dry and warm weather. He has several times been surprised to see a very large number of failures in one month, immediately succeeding a month when a great many cures had been registered. This circumstance should be known, that the true influence of croton oil may be understood; for if this is not taken into account, observers who collect cases of colic, treated by this medicine at different seasons of the year, might arrive at somewhat opposite conclusions.

Such is the method which cures soonest and quickest, relieves most speedily, most certainly protects from relapses and cerebro-spinal lead diseases, individuals who are attacked with lead colic. Tanquerel asserts this with a certainty warranted by long experience, and the impartial severity which he used in the therapeutical investigation of the medicines employed in this disease; he pronounces this mode of treatment to be the best; it takes the place advantageously of the best method formerly used, that is, the treatment of the "Charity," as well from its superiority as a therapeutical means, as from the facility of its administration. Tanquerel hopes that his work may help to extend the use of this excellent method, whose benefits are each day multiplied, and to the propagation of which he would be glad to contribute.

Finally, croton oil is not a specific remedy in lead colic. If a vomu-purgative substance should be discovered, which in as small a dose would give as violent a shock to the abdominal organs as this does, it might be used with as much success. But as this substance has not yet been discovered, Tanquerel advises every physician who treats lead colic to use this powerful remedy, according to the directions which have been given for its administration, and which will now be repeated here as

propositions or conclusions; for if these rules are not observed, the desired effect will be delayed, or perhaps never take place.

Mode of administering Croton Oil.

The best way to administer croton oil, is to give a dose of one drop in a spoonful of ptisan, on the first visit to the patient. If this first dose does not produce evacuations or vomiting, seven or eight hours after, another drop must be administered, or a purgative clyster.

The next day, and the day after, croton oil should still be prescribed in the same manner.

The fourth day, when the patient is entirely free from all the symptoms of colic, a second purgative clyster should be administered, which should be continued till the seventh or eighth day.

In rare cases, where the colic has not entirely ceased the fourth day, a drop of croton oil must be again given, and this may be repeated the day following, if by chance all traces of the disease have not disappeared.

When the patient vomits a quarter or half an hour after taking croton oil, it must be mixed with an ounce of castor oil; or administered in clysters, in double the quantity prescribed when taken by the mouth.

At the same time that croton oil is given, it is well to use a large quantity of ptisan. Most of the patients drank every day a very large quantity of honeyed barley water.

THERAPEUTIC INDICATIONS.

Some observers have thought, *a priori*, that the treatment of lead colic, ought to differ according to the patient, or the greater development of some symptoms, &c.; that, in a word, there are therapeutic indications which should vary the medicines, used in this disease. To conquer this violent pain which characterizes the disease, and controls the other symptoms, it is necessary to act with energy. It would seem at first, that opiates would answer this indication, yet it has been shown that disturbing means, such as drastic vomipurgatives, change and overcome this violent suffering more easily than the calming method. The infinite efforts, but often useless, that the patient makes to vomit and evacuate, do they not also indicate, that it is necessary to

open a passage for the excrements contained in the digestive organs?

Tanquerel has not observed that the constitution of the subject, his temperament, and an infinity of other circumstances, pertaining or not to the organism, permit special therapeutic indications to be established. Among the forms of simple colic, only one requires, sometimes, a peculiar mode of treatment; it is, when the symptoms are seated chiefly in the epigastrium, and very frequent vomiting takes place. It is then necessary to administer remedies by the anus, for medicines are scarcely taken, when they are rejected by vomiting, and consequently have no effect. But these cases are very rare; sometimes medicines, even vomipurgatives, cause the vomiting to cease; or excite it only after they have been a long time in contact with the digestive mucous membrane.

Lead colic complicated with other diseases requires peculiar treatment.

In most complications, lead colic must not be treated as if it existed alone; the treatment requires great caution. If the complication is an acute disease, it must be overcome before attacking the colic. This course must be pursued when there is an inflammation of the digestive tube.

Yet, if the affection with which it is complicated is chronic, and cannot be cured quickly, the treatment for colic must be immediately commenced; but it should be modified so as not to increase the gravity of the chronic malady. Thus, when colic is to be treated in an individual attacked with chronic gastritis, or cancer in the stomach, the remedies must be administered in clysters, or by the endermic method. When the patients have simple hernia, it must first be ascertained that it is well reduced, and if recourse is had to the evacuating method, drastic purgatives should be used as little as possible; and there is greater reason for following this advice, if, from any cause, the hernia is not reducible.

Albuminous nephritis requires less precaution in the use of drastic purgatives. Tanquerel has never seen any accidents in these cases, from the use of croton oil. Generally the treatment for lead colic, when complicated with an inflammation or organic lesion, is very long, on account of the delay occasioned from the fear of using means which might aggravate the complication.

When colic is complicated with a lead disease, for example,

lead encephalopathy, it is very difficult to introduce vomipurgatives into the stomach of the patient. Yet an endeavor should be made to conquer this difficulty; if it does not succeed, the remedies must be administered in clysters, or by the endermic method.

REGIMEN.

It is necessary, in the treatment of lead colic, even after the great pains have ceased, to insist for one or more days on the use of active remedies; it is the best way to prevent relapses. If slight uneasiness in the abdomen continues for some days, especially after the disappearance of violent pain, it is again necessary to use energetic treatment.

Severe diet should be prescribed during the whole course of the treatment; it is necessary to wait till the pain has completely ceased, before giving food. Tanquerel has seen the symptoms return with their first intensity, when food was given before the cessation of pain. A very small quantity of nourishment should be given at first, which may be increased daily.

It is necessary whilst the disease lasts, and even during convalescence, for the workman to be removed from the workshop, where colic was contracted. Some days after the cure should be passed without working, so that strength may be regained, before there is contact with lead.

END OF PART FIRST.

PART SECOND.

LEAD ARTHRALGY.

CHAPTER I.

DEFINITION AND SYNONYMES.

THE term Arthralgy is derived from two Greek words, one of which signifies pain, and the other means sometimes *articulation*, and sometimes *member*.

The name Lead Arthralgy is given to an affection of a neuralgic nature, produced by lead preparations. The following are its principal characteristics :

Lively pain in the limbs, without redness or swelling, not precisely following the track of the nervous cords, constant, but becoming more acute by access or crises, diminished by pressure, increased by motion, accompanied by various difficulties in mobility, such as cramps, hardness and tension of the painful parts. These neuralgic pains may also appear in the trunk, and in the organs of external life.

This affection is characterized by an exaltation of the sensibility and derangement of the contractility of the parts where it is seated.

Authors not having particularly directed their researches to this lead disease, have not attempted to give any definition of it.

SYNONYMES.

Most authors who have written on lead colic, and who have mentioned pains in the limbs in individuals attacked with that disease, have given no name to this affection.

Sauvages calls these pains in the limbs *metallic rheumatism*. This name is wrong, for it will be seen that lead arthralgy differs entirely from rheumatism. It corresponds in some degree to the lead rachialgy of Astruc.

CHAPTER II.

HISTORY.

Most observers who have published works on lead colic have spoken of pains in the limbs experienced by persons attacked with that disease.

Ætius says that those who swallowed litharge and white lead felt burning pains in the joints.

Citois, in his dissertation, mentions severe pains in the soles of the feet, thighs, and in the region of the sacrum, alternating with pain in the abdomen.

Stockhausen endeavors to prove that the burning heat of the joints, and even the pain in the muscles, are produced by the lead passing from the abdomen to the limbs.

The following passage is found in the *Colique des fonderies*, de Henkel: "The pains in the limbs should not be regarded as an accident of colic of the founderies, but as the disease itself, appearing in another form, and occurring only when the pains in the intestines have ceased."

Huxham, Dehaen, Dubois, and Gardane, regard pains in the limbs as precursors, or the first degree of paralysis; consequently, they have confounded these two lead diseases, which, however, they consider as consecutive effects of lead colic.

Astruc dwells much in his thesis on the seat and nature of the pains which occupy the loins; he observes that they extend even into the parietes of the thorax, the upper and lower limbs.

Bonté remarks that the limbs share the pains of the abdomen, and are sometimes cramped, which occasions much suffering. Stoll writes that after the lead symptoms appear in the abdomen, the limbs, arms, thighs, and legs, also begin to be painful, as in very acute rheumatism. In some it is lumbago, in others sciatica,

which extends even to the ankles, in others the articulations of the fingers, hands, and feet, are more affected than the muscles, whilst the opposite takes place. Sometimes the pain consists only in lassitude, or a pricking sensation.

Desbois (de Rochefort) also notices, in lead colic, rheumatic pains, which appeared acute and sciatic.

In the works of Merat there is the following passage with regard to this disease: "We see pains in the limbs accompany lead colic; they yield to the medicines which cure that. These pains are generally seated in the upper limbs, sometimes in the thighs and legs."

Palais compares these pains to rheumatism.

In the *Clinique* of Andral is the following remarkable passage: "The most common of the nervous disorders of the external life produced by lead particles, consists in pains in the limbs, and especially in the arms; these pains often precede colic; sometimes they constitute the only accident, and the functions of the digestive tube are not affected; hence we must conclude, contrary to the opinion of some authors, that they are not purely sympathetic with the intestinal affection." (3^e edit.) The same observer says, "these pains are often accompanied with paralysis of motion."

Renauldin, Canuet, Thomas, and de Bouteville, acknowledge that lead may exercise a deleterious influence directly on the nervous cerebro-spinal centre, and cause pains in the limbs without producing colic. But they have not distinguished from one another the different diseases which result from the influence of lead on the nervous system of external life; thus they classed under one head, pains in the limbs, delirium, epilepsy, coma, and paralysis, and called them *lead encephalopathy*.

Grisolle has described carefully the pains in the limbs, loins, thorax, and head, that came under his observation in patients attacked with lead colic.

Such are the documents furnished by the annals of science on one of the most frequent lead diseases. Authors have given no detailed description of it. Most of them imagining that pains in the limbs are only a sympathetic effect, or an appendage of lead colic, have not sufficiently fixed their attention on them; and they have scarcely done more than just mention them in their writings.

CHAPTER III.

CAUSES, PREDISPOSITIONS, AND PRECURSORS.

NEXT to colic, arthralgy is the most frequent lead disease. Tanquerel has observed seven hundred and fifty-five cases of this affection. In two hundred and one cases it was the only sign of lead disease; in all the other cases it was associated either with lead colic, paralysis, or encephalopathy. The simultaneous presence of colic and arthralgy in cases of lead poisoning, is so frequent, that it might be presumed the causes of these two affections are very analogous. It may be safely said, that both result from the absorption of lead particles into the system. But does this absorption take place in the same circumstances? This will now be examined.

Percival relates a case of an individual, whose lower limbs were scalded with boiling water, who experienced severe pains in those limbs from the application of Goulard's extract to the parts that were deprived of the epidermis by the accident.

Tanquerel saw lead arthralgy appear at the same time with colic, in a man who had used a collyrium of acetate of lead. Another person taken with lead colic was attacked with arthralgy from using acetate of lead in an injection into the vagina.

In several cases of colic, occasioned by preparations of lead taken into the digestive organs, in medicine, drink, or food, arthralgy appeared at the same time, or before or after the abdominal disease.

Those individuals who most frequently contract lead arthralgy, are workmen engaged in preparing lead for the arts. It has been observed that the workmen who most frequently suffer from colic are also more subject to attacks of lead arthralgy. There is one great exception to this rule. Workers in red lead manufactories are much more subject to arthralgy than to colic; among the patients, sixty-three were attacked with the latter, and four hundred with the former disorder. Of two hundred and one patients attacked with simple lead arthralgy, unaccompanied by other lead diseases, sixty-eight labored in red lead. Now, if it is remembered that there are not more than twenty red lead

manufacturers in Paris and its environs, it cannot be doubted that this substance produces arthralgy more easily than all other lead preparations.

It may then be concluded : 1, that lead arthralgy is developed only by the absorption of lead preparations by the sub-cutaneous cellular tissue, the mucous membrane of the organs of respiration, of vision, and generation ; 2, that this lead affection appears in workmen with a facility, in proportion to the dissemination in the atmosphere in which they work, of a greater or less quantity of lead particles.

PREDISPOSITIONS.

All the external circumstances which produce lead arthralgy are nearly the same as those in lead colic.

Colic, and other lead diseases, predispose to a certain extent to arthralgy, since the lead in the system may suddenly act on the organs of external life, and render them painful.

It might be thought, *à priori*, that a person seized with violent colic would be more liable to an attack of arthralgy than one with a moderate or light form. It is not so: the violence of the colic has no influence on the development of lead pains in the limbs and trunk. In five hundred and twenty-five cases of colic where there was arthralgy, the former was violent one hundred and eighty-six times ; moderate, one hundred and seventy-two times ; and slight, one hundred and sixty-seven times.

Some persons are attacked with arthralgy every time they experience symptoms of lead poisoning ; others, whenever they have an attack of lead colic, paralysis, or encephalopathy, are affected at the same time with lead arthralgy ; lastly, some individuals placed in the same situations for the absorption of lead, as those in the two preceding categories, yet are never tormented by lead pains in the limbs, trunk, or head. What occasions this organic predisposition to the development of this form of lead disease ? By what signs can it be recognised ? These are questions of etiology, unanswerable, like many others. Are not men every day placed in the same morbid etiological conditions, and yet experience different effects from the same cause ? Do not pneumonia, pleurisy, pericarditis, rheumatism, &c. attack equally a great many persons, who pass suddenly from a high to a low temperature ?

Recidivations and relapses are generally as frequent in arthralgy as in colic; they occur at the same interval, and in as great number in one disease as in the other.

PRECURSORS.

The characteristic phenomena of the primary effects, usually precede lead arthralgy, consequently, they may be regarded as the precursory phenomena of this affection. Sometimes, the sugary taste and lead jaundice precede, by a few days, pains in the limbs. The disease now under consideration, is generally announced previously, by a numbness and lassitude in the parts about to be attacked. This sensation lasts several days, and even months, varying in intensity from day to day, during all this time. Often, on rising in the morning, the workman experiences the first attacks of it; during the day, engaged with his work, he scarcely perceives it. Sometimes, but very rarely, this affection comes with rapidity, and suddenly reaches its greatest intensity. In seven hundred and twenty-five cases of arthralgy, colic preceded it two hundred and five times; lead paralysis five times; and once, lead encephalopathy was the precursor of the neuralgic pains in the organs of external life.

Arthralgy generally commences at night; it rarely shows itself when the workmen are engaged in their occupations, but when it does, they are immediately obliged to leave their work.

CHAPTER IV.

SYMPTOMS.

THE phenomena which characterize lead arthralgy, are pain, perversion of the contractility, and lesion of the functions corresponding to the affected organs. Pain is the most important symptom of this disease; indeed it may be said to constitute the whole of the affection.

This symptom varies not less in its nature, intensity, type, extent and progress, than in the multitude of parts which it

attacks. Nearly all parts of the limbs, trunk, and head may become the seat of the pain. Among all these parts, some are generally more affected than others. The lower limbs are most liable to attacks, next in order of frequency come the upper limbs, loins, thoracic parietes, back, and head. Of seven hundred and fifty-five patients, four hundred and eighty-five felt pains in the lower limbs only, eighty-eight in the upper limbs, eighteen in the loins, five in the thoracic parietes, four in the back or in the neck, and three in the head. One hundred and eight patients experienced pains simultaneously in the upper and lower limbs, thirty-five complained of pain both in the limbs and trunk, and nine in the limbs and head.

In one hundred and fifty-two cases, where the pain was seated simultaneously in the superior and inferior extremities, the trunk and head, in half the cases, it was more acute in the lower limbs than any where else.

Some modern authors have stated, that the pain of lead arthralgy was more frequent in the upper than in the lower limbs. This error undoubtedly arose from the fact that paralysis is much more frequent in the upper limbs, and they thought that the pain was merely an accompaniment of that. Certainly, this is a singular contrast between the seat of arthralgy and paralysis! Is it not surprising to see these two forms of lead disease, one affecting the upper, and the other the lower limbs?

Pains in the limbs are more frequently seated in the course of flexion, than elsewhere. Thus, for the lower extremities, the groin, posterior part of the thigh, calf of the leg, and sole of the foot; for the upper limbs, the arm-pit, anterior part of the arm, the fold of the elbow, palm, forearm, and hand, are generally the painful points. The parts situated in the muscles of extension, as the buttocks, anterior part of the thigh, knee, ankle-bone, and back of the foot, shoulder, elbow, posterior part of the superior limb, are less often painful. The pain is more frequently observed in the articulations, than in the continuity of the limbs. The small articulations, such as those in the foot and hand, are rarely affected. In the posterior part of the body, it is generally the lumbar region which is painful; sometimes the posterior parts of the thorax are attacked. Tanquerel once saw the pain follow exactly the track of the dorsal spine, and in this case, it also extended to the lateral parts of the spine. Several authors say, they have been more fortunate; but Tanquerel

is persuaded that they mistook pains in the lumbar and dorsal regions, for pains seated in the spine. Several patients, who complained of suffering in the vertebral column, when asked to place their finger on the painful point or points, never placed it on the spine, but always at the side. Ollivier (d'Angers) pretends that he has observed lead pains in the limbs, extending the whole length of the spine to the breast, the movements of which were painful, occasioning marked constraint in respiration, especially when the patients desired to make a deep inspiration. "In this case," adds this distinguished physician, "we may reasonably suppose that the spinal marrow is directly affected." Desbois (de Rochefort), Andral, and Tanquerel, have seen cases of lead pains which counterfeited angina of the breast; but they never observed radiations the whole length of the breast. Ollivier reports no observations in support of his statement; it would therefore appear, that this assertion rests only on a theory of this physician in regard to this lead affection; a theory, however, which Tanquerel believes to be true.

The pains in the thorax may be seated in different parts of its parietes. When the head is the seat of the pain, the face or the scalp is the point from which the pain radiates. Nothing is more variable than the limits of the pain; it may occupy one, or many of the parts just mentioned; sometimes, but very rarely, it extends along the whole length of one or several limbs; but it has not constantly in all the parts the same intensity, nor the same character. The pain is generally dilacerating, bruising, or else composed of excessively painful shootings, which are produced abruptly and rapidly like electric shocks.

Some patients compare the pain they feel to that which a sharp instrument, like a needle, would produce, in traversing one or more times the affected part; or else, to the boring of a gimlet. Some say, the pain is like a burning coal inclosed in the painful tissues. Others, complain simply of a pricking feeling, an inconvenient numbness, a sensation of fatigue or oppression, a sort of constriction or crispation. Some complain of a biting sensation; others, of a creeping feeling, like that produced by the motion of a great many ants. Finally, some imagine that a burning liquid is coursing through their veins; or that they feel the pressure of an icy cold substance.

The intensity of the pain varies from a simple uneasiness, an uncomfortable sensation, to the most dreadful sufferings. The

degree of the pain does not generally continue the same. It usually experiences exacerbations, from one moment to another it acquires more acuteness, and soon after diminishes. At the moment of the paroxysm, when the pain is violent, the patient is a prey to the liveliest agitation, his face is distorted, he utters lamentations and cries, incessantly changes his position, throws his limbs out of bed, applies them to cold substances, presses the most painful parts with his hands, in hope of alleviating his sufferings. After one or more minutes, calm returns. In the interval between the crises, the pain does not wholly cease; as is the case in certain common, periodical neuralgiæ, it only lessens in acuteness; the patients then commonly complain of a feeling of numbness, pricking, fatigue, oppression or constriction in the part affected; whilst, during the paroxysm, these unfortunate sufferers compare it sometimes to an electric discharge, sometimes to darts of fire, or else to a boring, dilacerating sensation, &c.

At times, the slightest cause, as motion, cold, is sufficient to bring back the attacks, which usually occur at equal intervals. In certain cases, the pain is exasperated so often that there seems to be no remission. But generally the crises are most marked, where the pain is most violent. The time between the exacerbations varies from a few minutes to whole hours, and is not the same in successive attacks. Their duration is rarely long in the first stages of the affection.

As soon as the disease reaches its most acute period, the attacks are more marked; in proportion as the excitation diminishes, the crises become less sensible; finally, the patient suffers almost incessantly; nevertheless, some more lively shocks still agitate him from time to time. The exacerbations generally occur in the night. Stoll, Desbois (de Rochefort), Gardane, Merat, &c., have also remarked this.

Arthralgy is violent, moderate, or light, according as the pain is more or less acute. Of the seven hundred and fifty-five patients, nearly one fourth were attacked with violent pains, half with moderate, and the other fourth with light. Thus, colic is more frequently violent than arthralgy.

Pain is often diminished by slow and gradual pressure, especially at the moment of the exacerbations. Sometimes simple friction relieves, whilst strong pressure increases the pain; the contrary effect is also produced. In some cases,

pressure does not change the intensity of the pain, but it even increases it. Tanquerel saw two patients, attacked with lead arthralgy in the lower limbs, in whose thighs all the muscles were seized with spasmodic agitation when the hand was brought near to the painful parts.

The pain is accompanied by some local symptoms which depend on disorders in the functions of the painful organs. The muscles are affected with spasms, contractions, cramps, or rigidity, a more or less apparent kind of tetanic state, the *trismus dolorificus* of Sauvages. Sometimes the disease consists only of cramps; in their interval, the patient does not suffer. In certain cases, the muscles are agitated, with a more or less intense trembling or quaking motion. This perversion of the mobility is well marked only in cases of violent arthralgy.

The patient is conscious of the cramps with which he is attacked; the physician also may recognise them by touch. When the pain is violent, the muscles, contracted with energy, form unequal and very hard tumors; the limb is deformed. Cramps cause the patients violent suffering; when the lower limbs are affected, they throw themselves out of bed, and place their feet on the floor, to stop these painful spasms. Cramps generally return only at the moment of the exacerbations.

Communicated or spontaneous motion of the part, where the arthralgy is seated, often aggravates and exasperates the pain; and yet, the most severely affected patients constantly change their position and place, in hope of moderating their acute sufferings.

Generally, in case of violent arthralgy, when the painful part is affected with involuntary spasmodic contractions, its motion is uncertain, incomplete, and irregular. The muscular fibres, whose contraction increases the sufferings, are no longer easily controlled by the will. Thus, for example, when the calf of the leg is affected with cramp, it is impossible to perform any motion of the leg with its usual precision and extent. The pain, as well as the morbid contractions of the muscles, are then an obstacle to regular motion; it is not abolished, but only difficult and uncertain; the pain is scarcely removed or diminished, when normal motion becomes as easy and as complete as before the attack of pain. Paralysis, or loss of all motion, from want of contractility, owing to the relaxation of the muscles, must not then be confounded with the partial loss of normal motion, in consequence of pain and morbid contraction.

There is no heat perceptible to the hand of the physician, neither redness, or morbid swelling in the parts affected with lead arthralgy. Once, after long and severe pains in the knees, Tanquerel saw a slight redness and swelling in the internal part of this region, but it lasted only a few hours.

Very often the patients cannot endure the heat of their bed; they suddenly throw the coverings off the painful parts. Others, on the contrary, avoid cold, as increasing their pain.

The pulse generally preserves its normal suppleness and regularity. In only fifty-five cases of arthralgy, without colic, it was hard, slow, vibrating, and, in seventeen cases, irregular.

The skin, muscles, bone, nerves, &c., of the limbs affected with arthralgy, are the seat of pain. The patients complain of pain in these different tissues, several of them said their bones were gnawed; cramps are caused by painful excitation of the muscles; in some cases of arthralgy the pain seems more superficial than deep; its acuteness is modified by passing the finger gently and lightly over the skin. The pain does not follow, exactly and exclusively, the track of the cords, ramifications, or branches of the nerves, which connect the cerebro-spinal axis with the organs of external life. Even when the pain appears to follow the direction of a nerve, as in the posterior part of the thigh, it does not extend through its whole length, it generally invades only half or quarter of this part of the lower extremity. All the nervous parts, which are in the painful region, and which are connected with the muscles, bones, and skin, appear to be the seat of the disease.

Are there cases, where the pain is limited to the skin, at other times to the muscles, and even to the bones, that is, to the nerves, which carry feeling to each of these tissues? It is difficult to answer this question in a positive manner, for here, as in lead anæsthesy, it is only by experimenting on the different tissues that one can be sure that the pain exists in each of them. The only light that can be obtained is from the sensations of the patient, and these may easily lead into error.

Tanquerel, after having made many investigations on this subject, ventures to affirm, that the pain may be limited exclusively to the skin, limbs, or bones. It may be said, in favor of this supposition, the pain being sometimes deep, and sometimes superficial, and accompanied or not by cramp, there are some reasons for believing that it may chiefly attack one of the above

mentioned tissues, that is, the nervous extremities connected with them. It may be added, that where cutaneous anæsthesia and lead arthralgia are concomitant in the same organs, it must be admitted, that the muscles, bones, &c., are exclusively painful.

Different functional derangements are observed, according to the different parts of the body affected. Thus, when the pains affect the lower limbs, they are often found bent in the different articulations. The patients extend them with some difficulty; they cannot stand or walk long at a time; the pain presents an obstacle to the regular contraction of the muscles which perform these different functions, and these motions increase the pain. If the calves of the legs are painful, they generally become hard as stone, in consequence of the temporary spasmodic contraction of the muscles in that part. In cases of arthralgia of the feet and thighs, the patients frequently complain of cramps, which are sometimes renewed by the slightest motion. Flexion of the articulations, and cramps in the fleshy parts of the upper limbs rarely occur, because they are seldom the seat of such intense pain as are the lower extremities.

In three fourths of the cases, the pain was seated at the same time on the two corresponding limbs, but rarely in the same degree.

In cases where the pain is felt in different parts of a limb, it has not, in all parts, the same character and intensity. Here, it is lacerating, accompanied with cramps, and darts rapidly as lightning; there, it is boring, and almost constant; a little farther on, it feels like pricking. After having continued in the same place for a longer or shorter time, it sometimes changes its character, and even place, through the whole limb; but it does not leap from one limb to another. In some cases it is more acute on the plane of the articulations. In other cases the intermediate spaces are subject to more severe attacks.

When the pain is seated in the back and loins, the patient can neither stoop or bend, without increasing the pains, and for the same reason, they, with difficulty, perform these motions in their whole extent. There are no difficulties in the urinary secretion, which distinguish these pains seated in the muscular masses, from those occupying the renal region in cases of lead colic.

If the thoracic parietes are painful, the respiratory movements

are constrained. The patient, from fear of increasing his sufferings, dilates the thorax as little as possible; a deep inspiration certainly increases it. The attacks of dyspnœa, counterfeiting angina pectoris, and sometimes observed in persons poisoned by lead, might, perhaps, be referred to the disease described as lead colic. The thoracic pains of lead arthralgy must not be confounded with those which are only irradiations of the pains of lead colic.

In one patient, affected with pains in the thoracic parietes, Tanquerel discovered that they extended to those of the abdomen. To assure himself of the real seat of these pains in the abdomen, the patient was directed to lie on his back, and bend his head on to his breast. During the motion executed by the abdominal muscles, the pain was increased. The hand, passed gently over the skin of the abdomen, produced a feeling of comfort different from the exaltation of sensibility which existed before pressure. In this patient there was no functional difficulty in the digestive and urinary organs, consequently, this pain in the abdomen could not be referred to a colic which did not exist.

A patient, whose face is furrowed by lead neuralgia, makes involuntary grimaces, and the features are distorted. The secretion of the nasal mucus is suppressed. Once, ear-ache accompanied pains in the face. Pain occupies, here and there, different points of the face, to which are simultaneously distributed different nervous filaments. When the scalp is the point affected, the patient scratches it very frequently, but does not complain of numbness, or dimness of sight. The disease is generally seated in the upper part of the head.

If the disease is in the neck, there is wry-neck. When the pains are violent, they banish all sleep. All the other functions of the system are in good condition, in case of simple lead arthralgy, unaccompanied by other lead diseases.

CHAPTER V.

PROGRESS, DURATION, AND TERMINATION.

In general, lead arthralgy does not progress from its invasion to its termination, by almost imperceptible gradations.

It has already been said, that its invasion may be abrupt, or slow, but progressive, or subject to exacerbations, and intermissions.

During the acute period of arthralgy, in cases where it affects a regular progress, it every day increases in a very marked manner, until the moment of decrease. When the progress of the disease is irregular, which is very common, the intensity of the symptoms varies from day to day. In a word, the alternations of better and worse appear very frequently, especially if the affection is not properly treated.

The pain generally becomes more severe in the evening and night. If, at the commencement of arthralgy, the pains are felt most violently in one point, which is usually the case, often, on the following day, the pain has changed its situation. When the whole extent of a limb, as the thigh and leg, is the seat of pain, from one moment to another, the suffering will disappear in one part of the limb, so that the two painful portions are no longer contiguous to each other; there will be an intermediate space not painful. The sensation caused by the pain is also subject to numerous variations during the course of arthralgy.

The transition from the period of acuteness to that of decline is generally rapid, sometimes abrupt. The disease entirely, or almost entirely, ceases from one day to another, from morning to evening. In some cases, the period of decline is long, the patients suffer but lightly, but these little pains disappear slowly and with difficulty. Finally, it is not very uncommon, when the symptoms are near their termination, to see them retrograde, returning to the period of acuteness.

The progress of lead arthralgy may be acute or chronic. In the latter case, ameliorations and recrudescences take place. Relapses may occur in a few days, or months, or years, after recovery from the first attack. The duration of this disease varies much. Properly treated, it lasts from three to six days. Left

solely to the efforts of nature, it may also disappear in the same time ; but it frequently lasts for weeks, or months.

In case of the co-existence of lead arthralgy and paralysis, the following is observed.

Arthralgy and paralysis do not generally occupy the same part ; one invades the upper limbs, the other the lower. One is observed in the course of the muscles of flexion, the other in those of extension. Yet sometimes arthralgy and paralysis of motion are seated in the same limb, and in the course of extension. Usually, arthralgy has already partly disappeared, when paralysis begins to be developed. In a few cases, arthralgy abruptly ceased, and paralysis appeared in the same limb. Sometimes, these two affections commence, and at first progress, together ; but one disappears soon, whilst the other lasts for months and years, and even the whole lifetime. One patient, scarcely cured of paralysis of the wrist and fingers, suffered severely in the same limb.

Most authors have regarded lead arthralgy as a symptom of lead paralysis. There is only one point of resemblance between these two diseases ; viz., their common origin. These diseases, or forms of lead poisoning, are independent of one another, but may exist simultaneously in the same individual.

In the case of lead poisoning, where arthralgy and encephalopathy co-exist, the cerebral accident generally appears in the midst of the course of arthralgy, which then ceases more or less abruptly ; yet, there are, sometimes, alternations in the predominance of arthralgy and encephalopathy ; Tanquerel has seen cases where the painful affection of the limbs survived the cerebral disease, and even with increased violence. Lead arthralgy hardly ever terminates in death. Tanquerel records only a single case which had such a termination, and has not heard of any other. This affection usually terminates by a return to health. In some cases, lead colic, paralysis, or encephalopathy occur at the termination of lead arthralgy. This disease may then be considered as not dangerous in itself ; yet, as the individual, who is attacked with it, carries in him the germ of diseases, mortal, or very difficult to cure, (lead encephalopathy and paralysis,) there is ground for serious anxiety with regard to the final issue. Consequently, every thing retarding its cure, may render the prognosis more grave.

CHAPTER VI.

DIAGNOSIS.

LEAD arthralgy may be confounded with rheumatism, common neuralgia, weariness, and sympathetic pains of the abdominal affections.

Acute rheumatism may easily be distinguished from lead arthralgy. In this latter malady there is neither swelling or redness of the articulations. In rheumatism, pressure increases the pain; the contrary occurs in the lead affection. The least spontaneous motion causes so much pain in rheumatism, that the patient remains as immovable as possible; violent lead pains in the limbs, cause the patient to change his position incessantly in hope of finding relief, which proves that he does not feel his pain much increased. The instantaneous appearance or disappearance of lead arthralgy, contrasts with rheumatism, which is some time in developing, and diminishes and declines by degrees. The painful parts in the lead disease usually occupy the fold of the articulations; the opposite side is generally the seat of rheumatism. Finally, the febrile movement and the complication of endopericarditis may distinguish these two diseases, which may be taken for one another by an unskilful observer.

Lead arthralgy more easily counterfeits chronic rheumatism. The absence of redness, and swelling, the exacerbations of pain, and want of the febrile movement, cause some resemblance between these two diseases. Sometimes chronic rheumatism is erratic, passing from one limb to another. Lead arthralgy is movable into different parts of a limb, but does not cease in one limb, when it goes to another. The duration is generally different, unless the first of these affections, left to itself, has become chronic. In this last case of lead disease, antiphlogistics, emollients, and even vapor baths have scarcely any effect on the disease; but administer sulphurous baths, treatment of the "Charity," or drastic purgatives, and it is surprising to see the

rapid amelioration, and cure of the pains that have been treated as rheumatism. The mode of treatment gives to the physician the means of forming the diagnosis of certain diseases. In chronic rheumatism, pressure and motion greatly increase the suffering; the lead disease is moderated by the first of these means, the second slightly aggravates it. Finally, in chronic rheumatism, the articulations become stiff, the extremities of the bones are swollen, and sometimes produce deformities in the limbs; nothing of this kind occurs in lead arthralgy.

Common neuralgia, not produced by poison, appears sometimes to be so nearly related to lead arthralgy, that some authors think there is a perfect identity between these two diseases; this is an error. In both, the pain is remittent, exacerbant, diminished by pressure, and increased slightly or not at all by motion. But in neuralgia, the pain only follows the track of a nerve. Tanquerel has never seen lead pain limited to this circumscribed track; it occupies several inches in width, which is very different from the line described by a nervous cord, the seat of the common neuralgic pain; the lead pain rarely extends as far without interruption, as neuralgia, viz., the whole length of a nervous cord. The pain produced by lead is seated sometimes by the side, sometimes far from a nervous trunk, in the fleshy part of the limb, and in the vicinity of the articulations. In lead arthralgy, from day to day the greatest degree of the pain changes its place, and a certain space of the healthy tissues separates two painful points in the same limb; nothing similar to this is seen in common neuralgia. Finally, in lead arthralgy, when a whole limb is the seat of the disease, different portions of this limb recover separately at unequal distances of time; whilst common neuralgia disappears at the same in its whole extent. There are but few acute abdominal diseases, which produce, at first, weariness, and bruising pains in all the limbs; but this painful state is vague, general, of short duration, and must not be confounded with the disease now under consideration.

Finally, lead arthralgy usually accompanies colic, paralysis, or encephalopathy. This circumstance adds much certainty to the diagnosis. It shows that this affection is developed in persons in contact with lead preparations. All these facts, such as the physiognomy of the disease, the profession of the patient, and other co-existing lead affections, will almost always distin-

guish lead arthralgy from all other affections. But it must be borne in mind, that the profession of the patient and the existence of lead diseases, cannot alone furnish the elements of the diagnosis. Lead workers may contract rheumatism, and neuralgia, even during the course of lead colic.

CHAPTER VII.

ANATOMICAL ALTERATIONS, SEAT AND NATURE.

NOTWITHSTANDING the most minute investigations in individuals who had succumbed during attacks of lead arthralgy, Tanquerel has found no perceptible lesion in the diseased organs, or in the nervous spinal centre. Ought we to be surprised, that the scalpel is powerless to demonstrate the nature of functional troubles which appear and disappear, sometimes with astonishing rapidity, and whose physiognomy changes every moment, although the seat of the disease seems to remain the same?

Devergie analyzed the muscles of the calf of the leg of a subject who had lead encephalopathy, and was also attacked with arthralgy. This skilful chemist discovered there a considerable quantity of lead.

SEAT AND NATURE.

The physiognomy of lead arthralgy, its progress, duration and the absence of anatomical alterations which characterize it, show that it consists in a purely nervous lesion, whose mode of alteration, even at the present time, is revealed to us only by its symptoms. The diseases which this functional alteration most resembles are neuralgiæ. The nervous spinal system is the source whence comes the sensibility which animates the skin,

muscles, bones, &c., which compose the parts affected with arthralgy. This exaltation of the sensibility of the organs of external life, must then be referred to a lesion of all the nervous fibres which communicate with them, and which are only prolongations of the nervous spinal centre. If, as it seems demonstrated, the organs of external life derive their sensibility, in particular parts, from the spinal cord, is it not probable, that lead neuralgia would have its seat in the nervous cords corresponding to that part of the spinal marrow which presides exclusively over the sensibility?

This neuralgia is only developed in consequence of the absorption of lead preparations, which give it a characteristic expression; lead arthralgy must then be classed under the head of neuralgiæ, from a specific cause. The peculiar mode of action of lead on the system to produce lead arthralgy is completely unknown.

If lead colic and arthralgy are compared, the greatest resemblance will be found between them; there is but one difference, viz., the seat. Arthralgy is in the organs of external life; colic, in those of internal. One is the perfect image of the other; causes, exaltation of the sensibility, perversion of the contractility and functions of the diseased organs; progress, duration, termination, prognosis, every thing is similar.

If it was desired to represent what passes in the abdominal organs of a person affected with violent lead colic, a case of arthralgy of equal violence should be observed.

CHAPTER VIII.

TREATMENT.

THE treatment used for colic, seems to many practitioners the best means for curing lead arthralgy. This opinion does not rest on very accurately observed facts.

With two hundred and one patients, attacked with simple lead arthralgy, without any complication, different medicines were used, which had a variable influence on its duration and termination.

In thirty-five cases, the disease was left to itself; recovery, nevertheless, took place, in from ten to twelve days, in twenty-two patients; the thirteen others, continuing to suffer after this time, were subjected to the use of sulphurous baths, and were cured in a few days.

Among eighty of these patients, treated by purgatives and opiates, (treatment of the "Charity," opiate clysters, &c.,) fifty-eight were cured after six or eight days' use of this medication; twenty-two, having obtained no relief, were very speedily cured by sulphurous baths.

Of eighty-six individuals affected with lead arthralgy, eighty were cured by the administration of sulphurous baths in four or five days, the usual time. Six resisted this medicine; their sufferings yielded spontaneously, after the ineffectual use of an infinity of remedies.

To obtain the most advantageous results from the use of sulphurous baths, they should be prescribed every day, for seven or eight days. Five or six ounces of sulphuret of potash is the quantity put into each bath at the "Charity."

Workmen, whose skin is impregnated with lead particles, after having taken sulphurous baths, are covered with sulphuret of lead. The formation of this sulphuret does not appear to have any influence on the pains experienced in the limbs, &c. Patients in whom this phenomenon does not take place are cured as quickly.

Five patients were subjected to the use of simple, aromatic, or vapor baths; these did not appear to have any salutary influ-

ence. These individuals were cured in nearly the same time as those who were left solely to the efforts of nature. It must then be concluded, that sulphurous baths are the most powerful remedy that can be used to cure lead arthralgy. This remedy does not need the aid of purgatives, in cases where arthralgy is not complicated with lead colic.

Yet, this latter remedy, having an undoubted influence on arthralgy, probably in consequence of the lively shock that it gives to the diseased limbs, may be employed simultaneously with the sulphurous baths, even in cases where the digestive and urinary organs are not affected by the lead.

END OF PART SECOND.

PART THIRD.

LEAD PARALYSIS.

CHAPTER I.

DEFINITION AND HISTORY.

PARALYSIS, in a general sense, is the loss or weakness of voluntary motion, and of sensibility, or of one of these faculties only. In a stricter sense, paralysis of motion is the loss, or evident weakness of voluntary motion, occasioned by a want of contractile power in the muscular fibres.

The paralysis produced by lead preparations, may consist in the loss of motion only, in the parts enjoying at once both motion and sensibility. In other cases, on the contrary, the sensibility only of these same parts is affected, and rendered unfit to receive impressions from exterior bodies, the power of motion remaining unimpaired. The first kind of paralysis is called the paralysis of motion, or simply, lead paralysis, and to the second is given the name of lead anæsthesy.

This distinction between lead paralysis and lead anæsthesy permits a separate description of these two kinds of lead paralysis, so different from each other, and which may exist single or combined.

Lead paralysis, properly so called, is characterized by a loss of voluntary motion, owing to the want of contractility of the muscular fibres of the organs invaded. Most frequently, the muscles which are deprived of motion are found in the extensors of the limbs. No morbid phenomena have been observed in the cerebro-spinal centre, which reveal the existence of an organic lesion, as the origin of lead paralysis.

The notices of paralysis do not descend from antiquity as remote as those of lead colic. Nicander being the first among ancient authors now known, who has spoken of lead paralysis. All the other ancient Greek, Latin, and even Arabian writers, whose names and works have been quoted in the history of lead colic, have described paralysis in their account of colic, and some of these, as Paul of Ægina, mention paralysis accompanied with loss of sensibility.

Paracelsus describes lead as mineral paralysis. And as we come down to the middle ages, from Avicenna in the ninth, to Fernal in the sixteenth century, little is written upon lead paralysis, and that little is a mere cursory notice or allusion to this disorder, with the exception of the letters on paralysis, written by Crato (de Kraftheim), who flourished in 1582, (*Cratonis, Epistolæ de Paralyti ex colica nata Scriptas*, iii. iv., *consilium* 10, 12.) In the seventeenth century, Stockhausen first attempted to define the particular muscles of the upper extremity which were most usually affected with paralysis, and the greater tendency of the extensors to this affection. In this period, also, appeared a little but valuable tract on lead colic, by Beauval, which has some judicious and acute observations on paralysis. The works of Riverius, and the *Dissertatio de Paralyti Metallorum*, (*Utray*, 1693) contain nothing not found in the preceding authors; and this remark may without injustice be extended to the early writers of the eighteenth century, Sydenham, Huxham, and Boerhaave, whose description of the atrophy of the paralyzed parts, is peculiarly forcible. In the middle of this period, appear celebrated tracts on painters' colic, in which paralysis is treated with an interest before unknown. Passing by the works of Astruc and Dubois, little worthy of notice in the history of lead paralysis as they were in that of colic, Dehaen, (*Ratio Medendi*, t. v.) of all authors, ancient or modern, has most accurately described the lead paralysis of the arms, legs and hands, and other parts of the limbs and trunk, giving an analysis of the several muscles affected, which leaves little to be added to his observations. He notices lead aphony, and the tumors on the carpo-metacarpal region.

The names of James (*Dictionnaire de Médecine*), Doazan (*Journal de Médecine*), and the publications of *L'Académie des Curieux de la Nature*, may be referred to as worthy of notice at this epoch. The name of Bonté, however, stands out in bold

relief, and his remarks (*Ancien Journal de Méd.* tom. xv. xvi. xx.) place him beside Dehaen.

The same Journal (t. xxii. t. lxi.) contains good papers by Strack, Professor at Mayence, 1765, and Planchon.

Desbois, Heberden, and Stoll, all speak of lead paralysis; Heberden, referring to lead, as a special example of poison affecting only the nerves of motion, and Stoll, after many exact observations which he relates clearly, says that the sensibility of the parts paralyzed is always exalted, never lost. He has also given some good observations on the treatment. In fact, all the writers at this period, whose names have been mentioned as authors in the history of lead colic, have also noticed lead paralysis, which they often regarded as a mere sequel of colic, or produced by its treatment. Few refer to loss of sensation independent of loss of motion. Merat, especially, denies primitive lead paralysis, and affirms that he has not known a well authenticated case of paralysis of the lower limbs. Andral in his *Clinique* has but few observations on lead paralysis, and these refer chiefly to treatment; and after a most patient search among published inaugural dissertations, and collections of French and foreign theses in the medical libraries of Paris, Tanquerel found not one especially devoted to lead paralysis.

CHAPTER II.

CAUSES.

If the circumstances are examined, under which this metallic paralysis is manifested, it will be seen that this affection appears under the same circumstances as colic and lead arthralgy. Thus lead, or its different compounds, in a state of molecular, or extreme division, introduced into the system, acts alone, after having been absorbed in such a manner as to develop the symptoms of the disease, the history of which is now being traced.

It is said that mercury produces paralysis. This is an error; this poison produces tremblings, called mercurial tremblings, but never paralysis. In fifty cases of mercurial tremblings observed

at the Hospital of Charity, not one was followed by paralysis. Nor do the other metals produce it, but lead only. Operatives in mercury, copper, tin, arsenic, &c. without any mixture of lead, are said not to be attacked with paralysis occasioned by these substances. Nor is there found among authors a single fact recorded under rigorous observation, that contradicts what is now advanced.

The skin seems, at first sight, a very easy channel for the introduction of lead preparations into the system to produce paralysis.

Percival relates several cases of paralysis occasioned by the topical application of lead to the skin. But in the observations related by the English author, the epidermis had been raised by vesicants, or by the action of the disease, for which the medicine had been applied.

Gendrin, in a letter addressed to the Academy of Sciences, June 2, 1834, pretends that all lead accidents, except colic, such as paralysis, &c. are produced by a combination of a layer of oxide, or of carbonate of lead, with the epidermis. On this idea, it is argued, that those who are exposed to lead, to whom are administered sulphur baths, or lotions of sulphuric lemonade, ought not to be attacked with paralysis, because lead is thus transformed into sulphuret or sulphate of lead, insoluble, and therefore without action upon the system.

Tanquerel has not remarked, like Grisolle, that the administration of sulphurous baths would prevent the development of paralysis, and therefore, it may be argued from this fact, that lead preparations penetrate through the skin to produce lead paralysis.

There is not known a single case of lead paralysis, observed with great accuracy, which has been produced by lead preparations applied to the skin, where the epidermis was preserved. Often, on the contrary, it is well known, that lead has been introduced through the digestive and respiratory organs, and produced this form of lead disorder.

The inhabitants of Amsterdam, while using water preserved in lead reservoirs, were often affected with paralysis as well as colic. Lead paralysis has often been produced by the use of wine, or beer adulterated with litharge. Two cases of colic, occasioned by acetate of lead, were accompanied by paralysis. It has been produced also by the use of butter adulterated with white lead, and by acetate of lead given as medicine.

A family, according to Van Swieten, which had been in the habit of using water contained in a leaden vessel, were attacked with paralysis; another family were also attacked with paralysis from using water charged with sulphate of lime, drawn from the well with a leaden vessel.

Lead particles on the surface of the mucous membrane of the respiratory organs are easily absorbed, and produce lead paralysis.

It will be seen by a statement of the occupations of those most frequently attacked with lead paralysis, that this is confined to those working in lead, which is disseminated in the atmosphere under the form of *emanations*.

Those only are attacked with paralysis who breathe the air charged with, or who swallow a certain quantity of lead particles.

It may therefore be concluded, that the digestive, and especially the respiratory organs, are usually the passages for the lead particles which produce paralysis.

TABLE

OF THE OCCUPATIONS OF 101 INDIVIDUALS AFFECTED WITH LEAD PARALYSIS.

Occupation.	No. Diseased.
Manufacturers of white lead,	31
“ minium,	6
Painters of buildings,	22
“ carriages,	4
Ornamental painters,	5
Grinders of colors,	6
Manufacturers of German cards,	1
Potters,	5
Refiners,	3
Plumbers,	3
Type founders,	4
Printers,	3
Lapidaries,	3
Cutters of crystals,	1
Manufacturers of acetate of lead,	2
“ sulphate “	1
“ chromate “	1
Total	101

It has been frequently observed that cats remaining some time in red lead workshops, always die from paralytic attacks. Even

rats in white lead factories become paralytically, and are easily then killed by the operatives. Horses, too, employed in these establishments, suffer from difficult respiration, caused, as is supposed, by the occlusion of the air passages, arising from paralysis of the recurrent laryngeal nerve. This affection may be removed by tracheotomy, and the introduction for some time of a canula; an operation which has often succeeded, if followed by removal of the animal from the manufactory.

Some lead preparations produce paralysis sooner than others. All those used in the arts are easily reduced to disseminable particles, and may produce paralysis. The paralyzing action of lead is not always felt immediately after its introduction into the system; it often remains there a long time without producing any result. In a great number of cases, paralysis does not take place till after the individual has worked a long time in lead, and has suffered repeatedly from its colic. Cases have also appeared in those exposed for a short time only to the lead preparations, and who have never been attacked with its colic, as will be hereafter noticed.

The following table shows the length of time that one hundred and two individuals were exposed to the contact of lead, before being attacked with paralysis.

Duration of Labor.	Cases.	Duration of Labor.	Cases.
8 days,	3	Brought up,	60
15 "	2	10 years,	10
25 "	1	11 "	4
1 month,	3	12 "	2
45 days,	3	13 "	2
2 months,	2	15 "	4
1 year,	8	16 "	1
18 months,	10	17 "	1
2 years,	4	18 "	4
3 "	8	20 "	6
4 "	6	22 "	3
6 "	6	25 "	4
7 "	4	52 "	1
	<hr/> 60	Total	<hr/> 102

Authors, both ancient and modern, as Dehaen, Stoll, Ramazzini, Andral in his *Clinique Médicale*, Percival, &c., report cases of paralysis not preceded by colic. Of the one hundred and two cases above, forty occurred without previous colic. It must

be remarked; that colic often disappears when other forms of lead disorder supervene.

In eighty-eight cases, where the subject had suffered one or more fits of colic, twenty-five at the moment of attack of paralysis presented no trace of the first named disease. In thirty-nine of the one hundred and two cases, paralysis was the sole form under which the influence of lead was perceived. The following table presents the proportion in eighty-eight cases of the number of attacks, in the same patients, of colic preceding paralysis.

Number of attacks of Colic preceding paralysis.	No. of Cases.	Number of attacks of Colic preceding paralysis.	No. of Cases.
1	25	8	3
2	15	9	3
3	9	10	3
4	8	12	1
5	7	14	1
6	5	15	1
7	4	20	1
		30	1

In sixty-three cases of paralysis accompanied by colic, this last preceded in sixty, and followed in three cases. Hillary, Huxham, and others think that the paralysis which accompanies lead colic, is rather an effect of the treatment to which the patient has been subjected, than a direct consequence of the action of lead. It has been shown, in the part upon lead colic, that, as paralysis in a certain number of cases was consequent to the treatment, whatever that may have been, so when left to its course, or, next to that, treated with sulphuric lemonade, colic long continued tends to paralysis sooner than in subjects not attacked by this disease. But paralysis is not as dependent on the treatment as is usually imagined. The greater part of the authors, who have written upon lead colic, have advanced the opinion, that paralysis appears only among those affected with violent lead colic. This assertion is entirely erroneous.

Among sixty-three patients attacked with colic attended with paralysis, twenty-five cases were violent, twenty-one moderate, seventeen light, before the last disorder appeared. After these statements, it is evident that violent colic does not contribute more than light or moderate to the development of paralysis.

There are individuals, who, every time they are attacked with colic, either violent or light, also suffer from paralysis. Others, on the contrary, attacked with violent colic never experience paralysis.

Cases also occur, after repeated attacks of violent colic, without paralysis, in which the patient afterwards suffers from these diseases conjoined.

These facts prove that lead paralysis is a disease distinct from lead colic; a direct effect of the action of lead upon the animal economy. It is not astonishing that paralysis should be developed most frequently among those individuals already attacked with colic, the most common form of lead disorder. The predisposing causes of lead paralysis are, in a great measure, unknown. They are to be sought independent of colic.

Are they due to peculiarity of constitution?

It may be imagined, that persons naturally feeble, and of a nervous temperament, would be more frequently attacked than others; but the contrary often happens. Persons of a sanguine temperament, and strong constitution, the lymphatic and nervous, weak and delicate, are alike subject to this disease.

Some, exposed by their trade, to lead preparations all their lives, have never been attacked with lead paralysis.

Others, on the contrary, the same in constitution and appearance, are frequently affected with this malady; while some others have had their fifth, sixth, or twelfth attack of paralysis.

It must be then concluded, that the influence of constitution and temperament, is far from explaining the difference observed in the frequency of the disease, in those subject to the same causes.

Among one hundred and two persons attacked with lead paralysis, forty were of strong, thirty-five of weak, and twenty-seven of medium constitution. It is more difficult to decide on temperament than on strength or feebleness of constitution.

In sixteen cases, however, the sanguine, in twenty-two the nervous, and in eight the lymphatic temperament, marked the subjects.

Has age any thing to do with lead paralysis?

The ages of one hundred and two affected with lead paralysis were

Below 20 years, . . .	9	Between 40 and 50 years, .	28
Between 20 and 30 years, .	24	" 50 " 60 " .	8
" 30 " 40 " .	36	" 60 " 70 " .	4

From these statistics it is seen, that persons from twenty to forty years are most frequently affected with this malady.

It seems well proved, that lead acts with greater facility upon those leading irregular lives than upon persons of sober and regular habits.

A person already diseased, and subject to many privations, would be more exposed to paralysis than one strong and well fed.

Has the state of the atmosphere any influence in the development of this disease?

Of the one hundred and two cases stated above, thirty-six occurred in summer, twenty-eight in spring, twenty-six in autumn, and twelve in winter.

This greater development of the disease in the warm season must be attributed in a great measure to the exposure of the workmen to lead during the season when most actively engaged in their trades.

Shall the greater frequency of paralysis, at a particular season, be attributed to the fact, that then lead is more easily absorbed and introduced by various sources? After all, the conclusion is irresistible, that some persons are more susceptible to the influence of lead than others.

Another very important fact in the etiology of this disease is, that those who have once suffered are more liable to a second attack.

It seems that lead emanations undermine the power of the system to resist destructive influence. To reproduce paralysis, it is not necessary that a person should be exposed again to the influence of lead.

Maréchal has observed many returns of paralysis years after the patient withdrew from exposure to lead. In all these, positive evidence of primary effects was distinctly noticed. But in whatever manner, or by whatever channel, lead may have been introduced into the system, it is soon taken up by the absorbing vessels and carried into the circulation. Lead being thus mingled, and, as may be said, *vivified* with the blood, enters all organs endowed with motion, and impedes the functions of life.

CHAPTER III.

PRECURSORS AND SYMPTOMS.

CERTAIN symptoms give notice of the approach of lead paralysis. They sometimes amount only to a sensation of lassitude, weight, and coldness, a numbness accompanied with debility, an unusual stupor, a certain inaptitude of motion in the parts threatened with disease. But these symptoms, being slight, disappear as the laborer becomes warmed with his work.

Pains of the head or spine are not precursors of paralysis; but a trembling, more or less severe, joined with the sensation of unusual stupor and heaviness, warn the patient of the approach of paralysis.

In others, the members affected with heaviness become fatigued by the least exercise, and the legs bend under the weight of the body.

The hand and fingers become numb, and, losing all their power, the tools fall from their grasp.

Paralysis may be limited to these precursors, and finally disappear. During this early stage the subject may continue at his daily work, perhaps unconscious of the presence of these primary symptoms during the day. But as night comes on, they may awaken the individual. This state continues for some time; soon, however, after some days, they cease, and the members affected are struck powerless. Such are the precursors where paralysis is not preceded by other forms of lead disease, but it has been already remarked that colic is often its precursor.

Sometimes, in cases of colic, when well treated and cured, the limbs will remain stiff. This increases, and is followed by weakness, ending in paralysis. When colic pains wholly cease, or are indefinitely prolonged, we have reason to expect paralysis of the upper or lower extremities, and Baglivi asserts, that sweating during colic is a certain sign of the attack of paralysis.

In eight cases encephalopathy preceded paralysis.

Sometimes the parts which are destined ere long to be paralyzed, experience an increase of sensibility, amounting almost to arthralgy; and this last disease precedes that affection. Lastly, sudden cases but rarely occur without noticed precursors.

SYMPTOMS.

As soon as the lead emanations have benumbed one muscle, in which action is controlled by the will, the loss of the motion of this part is the first morbid phenomenon which appears; then no effort of the will can move this muscle in the least degree: the nervous fluid is weakened, or neutralized, so to speak, by the lead particles, and the paralyzed organ condemned to complete repose. Sometimes, but very rarely, the paralyzed muscle may execute some obscure and uncertain movements, its action seeming to be but partially destroyed.

In fact, it is the general opinion of authors, both ancient and modern, that motion is never wholly impeded by lead paralysis. This may be explained. Lead paralysis occupying usually one or more, or even one set of muscles, the other muscles of this limb not being paralyzed, must necessarily impress upon it some motion.

Thus the limb, the muscles of which are paralyzed, executes certain motions, owing to the contractile power of the sound parts; but these motions are incomplete; because, to be perfect, they require the power of all the muscles. There is, then, on the one hand, a diminution of the general power of the limb; and on the other, a complete loss of motion in certain of its muscles; two states which must be carefully distinguished.

This is a very important distinction. To ascertain how far the loss of motion is impaired, there should be made an exact analysis of all the motions preserved in the limbs affected with paralysis, and of all those which are lost. In this manner it will be seen which of the muscles enjoy their contractile power, and which do not.

The extent and degree also of affection can be thus estimated. This manner of investigation has either not been used, or has been imperfectly employed; and from want of attention to it, many mistakes have arisen in the authors who treat of lead paralysis.

When all the muscles of the limb are paralyzed, then the loss of motion is complete. Paralysis is then partial, or complete. It is important here to remark, that in cases of protracted lead disease, when the patient is reduced to great weakness, all, or very nearly all motion is lost; the immobility may arise from the entire debility of the patient and prolonged rest of the locomotive organs. It is not the result of the direct action of lead.

In the one hundred and two cases, before mentioned, there occurred five cases of general loss of motion in the upper extremities, and one case only in the lower.

In all the other cases it was partial, limited to one muscle, or set of muscles, or even to one fascicle of a muscle.

TABLE

OF THE RELATIVE FREQUENCY OF THE DIFFERENT VARIETIES OF LEAD PARALYSIS.

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Usually, paralysis of the upper is co-existent with that of the lower limbs, trunk and vocal apparatus. In five cases out of fifteen, paralysis of the abdominal members existed alone.

Except in cases of general paralysis, it is always the posterior part of the upper limb which is affected, and the anterior part of the lower. All these muscles serve, more or less, as extensors, or for abduction or adduction. In the present state of science, it is impossible to explain the reason why lead should affect the extensors more than the other muscles. Sometimes paralysis exists in the same degree, in two opposite limbs, and

affects the same muscles. In other cases, the disease affects only one member.

Sometimes the two limbs may be affected in different degrees, and in different muscles, or in an unequal number.

In the paralysis of the limbs, some muscles alone being affected, while their congeners, and the antagonists are free, it results that the equilibrium between these same muscles being destroyed, motion occurs in an irregular manner, and the diseased part is drawn along in the direction of the contracted muscle, producing a more or less marked deformity, which the patient increases by retaining this false position. Paralysis of the vocal muscles, and of the respiratory apparatus, necessarily produces disorder of these functions.

Lead paralysis commences with a slight numbness and trembling, but ends in the total loss of motion. The degree of loss of motion is not proportioned to the extent of paralysis. The trembling consists rather in a slight agitation of the muscles than in alternate contraction and extension.

It is a trembling unlike mercurial, so marked for its extensive and almost spasmodic contractions.

Lead trembling should be considered as the first stage of paralysis. It is a sign of marked weakness in the contraction of the muscles. When the patient wishes to make a motion with the trembling parts, their contraction seems to hesitate, and he moves with uncertainty. There is always weakness in the parts affected with trembling, when there is no real paralysis.

Lead trembling, continued for some length of time, almost always ends in complete paralysis of one or more muscles of the affected part.

It is generally confined to one part of a limb, or one whole limb, rarely extends to two, but it may attack at the same time the upper and lower limbs, the lips, tongue and vocal organs. Sensibility may remain in the limbs, even though they undergo atrophy. Although lead paralysis is usually manifested only by loss of motion in the parts affected, whilst their animal sensibility is unaltered; yet this faculty is sometimes weakened, or lost, thus producing lead anæsthesy. More frequently it acquires an increased energy, or a greater or less degree of exaltation. This last is lead arthralgy.

Among one hundred and two cases of paralysis of motion, anæsthesy has been observed five times, and arthralgy eight, in

the parts deprived of mobility. In three cases of anæsthesy and paralysis, the sensibility of the limbs seemed entirely abolished, the muscles and the skin seemed alike insensible. In two other cases of anæsthesy and paralysis, the loss of sensibility was limited to the skin only, for the patient complained of violent, deep seated pains in the limbs; thus paralysis, anæsthesy and hyperæsthesy were found united. When hyperæsthesy is joined to paralysis of motion only, the patient feels pain in the skin, the muscles, and even the bones.

Amaurosis and lead deafness are rarely found with paralysis of motion; six cases only occurring in one hundred and two.

Even where sensibility is in the normal state, patients experience a sensation of fatigue and heaviness in the paralyzed parts, principally in the articulations connected with affected muscles. In such cases, it seems as if a great load was suspended on the joints, which presented an insuperable obstacle to motion from its weight. In twelve cases there was a marked sensation of continued coldness, both externally and internally in the paralyzed parts, and especially the extremities of the affected limbs, a coldness appreciable by the attending physician. The gentlest current of air of low temperature increased the sensation of icy coldness in the diseased parts. The loss of animal contractility, and the different lesions of sensibility, are generally the only phenomena presented by the paralyzed parts. Some writers have remarked that the pulse, in the paralyzed parts reduced by atrophy, was always slow, strong, and full. But in all patients observed by Tanquerel, the pulse was feeble, soft, easily compressed, and very slow.

The state of the parts necessarily indicates little energy of circulation, and this opinion is confirmed by the fact, that there have been observed infiltrations of greater or less extent in the limbs reduced to the last state of marasmus. The pulsations of the heart share in the weakness of arterial circulation, especially in cases of long continued paralysis. The blood drawn from the veins is very serous, and its fibrine diminished. Nutrition languishes in the paralyzed parts from want of action in the nervous influx. When paralysis lasts a long time, for months, or even years, then flaccidity, withering, an extraordinary emaciation of parts deprived of motion, is remarked.

The skin is whitish, pale, of a livid aspect, often yellow, tawny, rough, earthy, dry and shrivelled.

The epidermis appears to be thinner than usual, often falls off in scales; the subcutaneous cellular tissue entirely disappears; the skin is sometimes loose, and seems to be too large for the parts it covers. The fat of the cellular tissue is totally absorbed; the plumpness of the paralyzed parts entirely disappears; the flesh is soft, the volume of the muscles becomes much diminished; they stand not out in relief, and their mass is almost entirely annihilated. In fine, deprived of their vital principle and condemned to entire inaction, the secretion of fibrine, upon which the growth of these muscles depends, ceases.

When partial emaciation or atrophy arrives at the last degree of marasmus, the skin seems glued to the bones, the paralyzed parts are so much emaciated; the muscles, especially, are so thinned, that the contour of the bones is easily distinguished. If the paralysis attacks the whole of one limb, then this organ, abandoned to its own weight, stretches the ligaments and permits the head of the bone to leave its cavity. If the paralysis is limited to one muscle only, or to two, their atrophy contrasts singularly with the muscles of the neighboring parts, which not being diseased, have preserved all their prominence.

This disease, in short, when of long continuance, exercises a marked influence upon the entire system.

All parts of the body show signs of decay, of wasting like the affected organs.

It is a fearful spectacle to behold these persons so lead colored. There is then remarked a great dejection of the countenance, which is fleshless; the eyes are of a dirty yellow and quite spiritless, the nose is nipped, the cheeks hollow, and great languor is observed in the attitude and motions of the body, which resembles a skeleton, with transparent drapery.

The sufferers, as they drag themselves about from place to place, resemble rather walking corpses than living men.

To this state of emaciation succeeds partial or general infiltrations of the limbs, upon which soon appear large scabs, or gangrenous spots.

It seems that the emaciation of the paralyzed parts and the marasmus of the whole comes on much sooner in lead paralysis than in any other of its forms.

Occasionally the secretions of the mucous membrane become greater, and subject the patient to increased discharges and abundant expectorations.

In the case of general emaciation, the urine is pale, colorless, without sediment. The kidneys, without strength, no longer perform their functions.

Alkaline urine has been observed in three cases, without noticeable lesion of the urinary organs, or spinal appendages. After paralysis has ceased, the urine becomes acid, even before the complete disappearance of the disease. No case of retention of urine in consequence of lead paralysis of the bladder is known.

The paralyzed parts are often bathed in the morning by extremely abundant and clammy sweats, yet the perspiration often preserves its normal state, and is never suppressed.

The secretion of the lachrymal gland is sometimes very active, without the faculty of vision seeming impaired. With respect to the head and vertebral column, there is no pain or any other accident which reveals anatomical lesion as the cause of paralysis. When the cerebral functions are disturbed, or when there are pains about the spine, these phenomena arise from other lead diseases, encephalopathy, or arthralgy, which may happen to be combined with paralysis.

CHAPTER IV.

VARIETIES OF PARALYSIS.

Paralysis of the Upper Extremities.

LEAD paralysis of the upper limbs is the most frequent of all. Out of seventy-nine cases of paralysis of the thoracic extremities, the disease affected both limbs at once fifty-one times; twenty-three times it was in the left, and twenty-four times in the right limb.

The varieties of paralysis of the upper extremities are the following:

1. *General Paralysis.*

The limbs are pendent beside the body, to which they seem pasted; if raised, they fall like inert masses obeying the laws of

gravitation. In all the muscles of the arm, the forearm and hand, there is a slight involuntary trembling; but where great and continued efforts are made, there is a slight elevating motion perceived in the shoulder, and this is owing to the contraction of the trapezoid muscle.

And when the great dorsals and pectorals are not paralyzed, the patient may also, by aid of their contraction, direct the whole limb, and especially the hands towards each other before and behind. Paralysis of these last muscles of the trunk has been noticed only once.

The shoulder appears depressed, the articulations of the elbow, wrist and fingers are in a state of flexion, occasioned by the contraction of the flexors, the muscular force of which is much superior to that of the extensors.

The forearm and hand are placed in a position between pronation and supination.

The limbs obey all the motions given by the hands of another, for they do not appear stiff.

When it is considered how extensive and well defined are the nerves which are supplied to the upper extremities, it is manifest how great must be the want of contractile power when these nerves are affected.

Two cases of general paralysis of the upper limbs have been observed, in one of which there was an entire loss, and in the other, an increase of sensibility.

In three other cases sensibility was preserved entire. When a paralyzed limb is raised, the patient feels great pain through the whole length of the limb; but particularly in the arm-pit and about the shoulder blade.

A sense of weight affects the shoulders, wrists, and elbows; there is also a marked sensation of great coldness in the parts affected. Pulse feeble and irregular in long protracted cases.

The limbs are soon reduced to the last state of atrophy; but principally the shoulder, its bony projections being perfectly well defined through the integuments.

The defined line of muscles rapidly disappears.

All the other parts are in a state of leanness disproportionate to the rest of the body.

The hands often become very painful, œdematous, livid, the swellings increase in the evening and night, diminish towards morning and through the day.

The pectoral and grand dorsal muscles being paralyzed, respiration is sometimes slightly painful.

Aphony and difficult pronunciation always attend general paralysis of the upper extremities.

The miserable subjects of this disease lose all prehensile power; their painful existence depends on others.

They can neither feed, drink, dress, get up, or lie down, without assistance, and are happy only in possessing a sense of touch. The arms are no longer balancing staves to assist progression; they are now obstacles to locomotion. General paralysis, as above described, is always preceded by some of the following varieties of local affection.

2. Paralysis of the Shoulder.

Paralysis of the shoulder, or deltoid muscle, is usually found only when some other muscles of the upper limbs are paralyzed. This paralysis is easily known by the impossibility of raising the arm. The immobility of the muscular fibres of the deltoid is remarkable, in the midst of the different motions of the surrounding fleshy parts. Soon the top of the shoulder becomes flat and depressed, the deltoid seems almost entirely destroyed, then the loss of motion and atrophy of the muscles induce consecutive luxation of the humerus; the orbicular ligament of the articulation of this bone not being sufficient to retain its head against the glenoid cavity. The lesion of the circumflex nerve, which is distributed to the deltoid muscle, will explain the seat of this paralysis.

3. Paralysis of the Arm.

The arm extends, widening from the chest, and the forearm is found bent upon the arm; but it cannot be extended, for the posterior brachial muscle is no longer susceptible to the power of contraction.

The superior part of the radial nerve passes solely through the muscular fibres of the posterior brachial; its lesion will explain the seat of the paralysis.

4. Paralysis of the Arm, Forearm, Wrist, and Fingers.

Paralysis of the above four members is much less common

than of the three last named, and may therefore be described in the following section, merely observing that this variety is caused by the lesion of the radial nerve only.

5. *Paralysis of the Forearm, Wrist, and Fingers.*

In this variety of paralysis, the forearm and hand have experienced a twisted motion, thereby extending the elbow from the body. The forearm and hand are in permanent pronation; supination can no longer be performed.

The upper part of the radial edge of the forearm is no longer on a line with the lower part, which is twisted inwards, so that the back of the hand is inside, the palm outside.

The wrist, at nearly a right angle with the forearm, cannot perform the least movement of extension.

It is in a position between abduction and adduction, but the will can no longer direct these motions.

The fingers are bent upon the metacarpus nearly in the same degree as the wrist upon the forearm.

The last phalanges are very slightly inclined upon the second; the movement of extension is found totally destroyed, the fingers can bend only a little, and that in the direction of flexion. The phalanges of the thumb are bent inward, and have lost the motions of abduction and adduction. By these different abnormal positions of the limb, it is easily seen that the morbid principle has rendered inactive the supinating muscles of the forearm, abductor, and adductor extensors of the wrist and fingers; and consequently the loss of equilibrium of the muscular action results in an habitual predominance of contraction in the pronator muscles of the forearm, abductor, and adductor flexors of the wrist and fingers.

Should the patient try to close his hand, the wrist bends a little more than it does in a state of repose.

The lower extremities of the fingers correspond to the middle part of the thenar and hypothenar regions.

The last phalanges are scarcely inclined upon the second; they are never bent so much that the extremity of the fingers may touch the hollow of the hand, which thus cannot completely close.

But the flexors of the fingers are not paralysed.

Whence arises this obstacle to perfect flexure of the fingers?

In a normal state when the hand can be wholly closed, the

flexors incline the phalanges towards each other, so that they form among themselves nearly right angles; in these different motions of flexion of the phalanges, their extensors experience a marked lengthening; by this motion, the phalanges pass over a much larger space than the fingers do, when they touch their lower extremity to the thenar and hypothenar regions. But in the variety of paralysis now discussed, the extensors of the fingers have lost their elasticity, they cannot then elongate themselves enough to follow the motion of inclination that the flexors impress upon the phalanges.

This is the reason why the hand cannot be completely closed. Once closed, the patient has only to cease all voluntary contraction of his flexors, and it will open; the wrist and fingers return to their state of demi-flexion; without the extensors having any part in this so-called passive motion. The patient can hold large bodies only.

In consequence of the permanent contraction of the pronator muscles and especially of the flexors, the hand becomes rounded and the back of the hand arched.

This state is more marked in the carpo-metacarpal region, than upon the sides which are flattened.

Soon there are formed by degrees one or two long projections, upon which authors are not agreed.

Plater, Dehaen, Bonté, Desbois (De Rochefort), and Pariset, affirm, that in lead paralysis of the forearm, tubercles or nodes are always found; sometimes, in the regions of the carpus and metacarpus, sometimes on the tendons of the paralyzed muscles, sometimes on the articulations deprived of motion.

These little tumors have the form of filberts or beans, at first movable, painful, yielding under pressure, and immediately resuming their size from elasticity. In time these lose their mobility, acquire hardness, and impede the motions of the parts affected.

Some attribute these deformities to a metastasis of morbid matter from the abdomen to the articulations; others have attributed them to the absence of motion in the articulations, in consequence of paralysis, as then, it is said, the synovial liquor, thickened and accumulated, produces these bumps. Others attribute them to a transformation of the sheath of the extensors of the fingers.

Chomel, Merat, and the greater part of modern authors, do

not admit the existence of these deformities on the back of the hand. Both opinions are equally erroneous. In the variety of paralysis now under consideration, small tumors constantly occur in the carpo-metacarpal region; but the authors cited above have not understood the nature, cause, form, and situation of these bony projections; their opinion has been refuted by those holding the contrary belief.

Since, in consequence of the contraction of the flexors of the wrist and hand, the back of the hand tends always to round itself, to swell and project forward; the ligaments which unite the bones of the wrist and metacarpus are distended beyond measure; then the bones glide over one another, and so produce projections more or less marked.

These projections are often formed by the head or upper extremity of the second or third metacarpal bones, to which the radial muscles struck with paralysis are attached; and which, consequently, are no longer able to retain these bones in contact with their corresponding surfaces.

Sometimes the scaphoid and semilunar bones constitute these pretended nodes; these little tumors have an extent of six or seven lines; the first, inferior, is conical and smaller; the second, superior, is flatter and larger. The posterior and external faces of the forearm are usually emaciated to such a degree that they are flattened, and their fleshy masses seem glued to the bones; whilst the anterior face often preserves its volume and normal form, and seems unnaturally enlarged, in consequence of the predominance produced by the continued contraction of the muscles in this region. In long protracted cases of paralysis, even the healthy muscles are wasted and suffer atrophy, by long repose, but in a degree less than those paralyzed. In many cases, in consequence of the permanent contraction of the flexors, their length and thickness diminish at the same time that they grow harder; they then form, especially in the inferior part of the lower arm, inflexible cords, which impede the extension of the wrist and fingers. The whole hand partakes of the muscular weakness brought on by long disease. The thenar region, when to the paralysis of the abductors is added that of their opposing muscles, is nearly level with the hollow of the hand.

At length the arm itself becomes wasted; its muscles, although healthy, are often condemned to repose, their movements almost always combining with those of the forearm and hand for

different wants of life. The pulse is feeble, soft, and slow; respiration is generally in a healthy state, but a little aphony or stammering, indicating paralysis of the vocal apparatus, is often observed. The other functions are not usually disturbed unless in long protracted cases, when the whole system is affected, though slowly and gradually.

To point out here, in an exact manner, the cause of paralysis in a particular lesion of the nervous system which is distributed to the paralyzed parts, it would be necessary to admit that the inferior part only of the radial nerve was affected.

6. *Paralysis of the Wrist and Fingers.*

The symptoms of this variety are nearly the same as those of the preceding, except that here, the forearm and hand, instead of being in pronation, are in a position between pronation and supination, because the supinating muscles are not paralyzed.

The supination of this portion of the upper extremity is made with great facility. These parts have not experienced any twist, and the crest of the radius has not undergone any deviation. When the forearm and hand are in supination, the flexors not contracting with much force, the wrist and fingers, abandoned to their own weight, appear a little extended.

In two cases of this variety of paralysis, there was an incomplete loss of the extension of the wrist. In these two cases, the wrist and the hand, in a state of repose, were presented in abduction, in consequence of the permanent contraction of the radial and want of action in the posterior cubital muscle.

The concavity and convexity existing in the normal state, at the cubital and radial edges of the wrist, disappeared, and were replaced, but slightly, by an opposite conformation. The wrist, when the hand was previously closed, could then be straightened in a line with the forearm; but in this motion it was only carried with the hand in abduction. Subjects affected with lead paralysis of the wrist and fingers, are able to dress themselves, to eat, &c.; operations which cannot be accomplished in case of paralysis of the forearm, wrist and fingers. To explain this form of paralysis by an affection of the nerves, it is necessary to admit the lesion of the branches of the radial nerve, which alone supply these paralyzed parts.

This is not easy to conceive of, or suppose, except upon considerations purely anatomical.

7. Paralysis of the Wrist.

The wrist is much bent upon the forearm by the habitual contraction of the anterior cubital and palmar muscles. But it may be a little more bent than usual by the will of the patient. As soon as this ceases to contract energetically and voluntarily the flexors, the wrist returns abruptly and mechanically to a position bent at a right or obtuse angle, the extensors taking no part in this motion.

The motions of the extension of the wrist upon the forearm cannot be performed; the radial and posterior cubital muscles are then paralyzed. The abduction and adduction of the wrist and hand cannot be performed, in consequence of the permanent contraction of its flexors, and the paralysis of its extensors. Sometimes, the motions of extension, abduction and adduction of the wrist are partially annihilated. Thus it may happen, that the posterior cubital muscle has only lost the faculty of contraction; then the wrist is turned outward at the radial border, by the radial muscles remaining sound; the concavity that it describes in a normal state in the length of its cubital border disappears, and is replaced by a convexity; the radial border becomes by that even a little concave. If, on the contrary, the radial muscles are affected with paralysis, the wrist turns inward, and the radial border, instead of following a right line, as in the normal state, describes a decided convexity, whilst the cubital border shows an unnatural concavity. In these two cases of paralysis, the wrist being in a state of repose and half bent, the patient may still bring it in line with, though he cannot throw it backward upon, the forearm. During this motion, the wrist is directed in adduction, if the radial muscles are deprived of contractility; in the case where the cubital is alone powerless, the wrist on the contrary, is directed in abduction, during the motion of extension made by the radial muscles. In the general or partial paralysis of the extensors of the wrist, the fingers bend or extend at will upon the metacarpus; the hand may be closed completely. The movements of opposition, of abduction and adduction of the fingers are performed perfectly well, as also those of pronation and supination of the forearm and hand. When the patient closes this last, the wrist seems to be directed a little in extension; but this little movement is

owing to a slight contraction of the extensors of the fingers and not to those of the wrist. The second and third metacarpal bones make a little prominence upon the back of the carpo-metacarpal region.

The internal and external sides of the forearm, which, in a healthy state, make two muscular projections, between which the fleshy mass of the extensors and the other muscles of the back of the limb are lost, become yielding, flattened, and upon a level with these same parts that they pass over.

It is difficult, nay, quite impossible, to refer this variety of paralysis to a lesion of any particular portion of the radial nerve, whose branches are so extensively distributed to the forearm.

8. *Paralysis of the Fingers.*

Lead paralysis may be general or partial, affecting all, or one or more of the fingers.

1. The rarest case is, when all the fingers are paralyzed in the same degree. In this case, all their extensors, and the interosseous abductors and adductors have lost their motion. In a state of repose, the fingers are bent at a right angle with the metacarpus, the last phalanges are slightly inclined upon the second; they can no longer perform the slightest movement of extension, their movement of adduction and abduction is incomplete, and can be performed in part only in the direction of flexion.

The patient may close his hand; in this motion, the lower extremity of the fingers touches only upon the thenar and hypothenar regions. To open the hand, or to bring back the fingers to their usual degree of flexion in a state of repose, it is sufficient that the flexors be not voluntarily contracted. In this return to a demiflexion, the extensors have no influence. If motions of supination, extension, abduction or adduction of the wrist are performed, on the upper part of the back of the forearm can be seen, very distinctly, energetic contractions of the supinators, radials, and posterior cubitals; and in the middle of the two fleshy masses that these muscles then form, is presented a much circumscribed muscular portion which is deprived of contractility; this is formed by the extensors of the fingers. The thumb bent and directed decidedly towards the palm of the hand, cannot be extended or perform abduction. Its motion of opposition is lost.

Its motions of flexion and adduction cannot be performed perfectly, in consequence of the paralysis of the extensors and abductors, which do not elongate sufficiently to facilitate these movements.

The motion of opposition of the little finger is often preserved. The patient cannot meet the extremity of his fingers, so as to form a pyramid, of which they shall be the summit, and the metacarpus the base.

That the fingers may be brought towards each other, the abductor, adductor, and opposing muscles must be used, which are now deprived of contractility.

The wrist appears much more bent upon the forearm. Its movement of extension cannot be completely performed, unless the hand has been previously closed.

In a state of repose, the flexors of the fingers being in a partial state of action, guide the wrist also in this motion, but that cannot surmount their force of contraction, or raise the fingers with it.

When, on the contrary, the hand is closed, the fingers constitute no longer a fixed weight at the end of the wrist, which must be raised before that can extend.

Extension may now be easily performed, since the muscles, preserving all their contractility, have the wrist only to move. As soon as the hand opens, the weight of the half bent fingers causes a slight flexion in the wrist itself.

If the wrist recovers its true position, adduction and abduction are performed with great ease.

It might easily be believed, that paralysis of the wrist would always accompany that of the fingers; but by closing the hand, the movement of extension of the wrist can be often performed in this position. The form of the hand is found modified; its back is swelled, much rounded, whilst the palm is found hollow.

The thenar and hypothenar regions have, in part, lost their relief.

2. Usually, the fingers are not all paralyzed, or they are so in different degrees. Generally, the middle and ring fingers only, have wholly lost their motion of extension, while that of the fore and little fingers is partially affected. In this case, the middle and ring fingers are bent at right angles to the metacarpus. The indicator and little fingers are, on the contrary, slightly bent and situated much below the others; their back always

describes a light curve in extension, which may be accomplished in part, but not completely. The separation of the fingers takes place only imperfectly, and that during flexion only.

Here evidently is paralysis of the common extensor of the fingers, and of the inter-osseous muscles, and preservation of the mobility of the extensors belonging to the first and fourth finger. When the patient closes his hand, the extremity of the middle fingers touches only upon the middle part of the thenar and hypothenar regions; while that of the fore and little fingers nearly reach the hollow of the hand.

Sometimes the middle and ring fingers have only lost the movement of extension in the same degree or unequally; in this case the fasciculi of the common extensor, which belong to these fingers, are paralyzed. The thumb has sometimes preserved all its motions; but most commonly its motions of extension and abduction are incomplete. There is only paralysis of the great extensor and abductor muscles. Sometimes this last muscle is alone paralyzed; then the movement of abduction only is incomplete.

When the two abductor muscles are paralyzed, and especially the smaller one, the motion of opposition is lost. One case has been observed, where the motion of adduction alone was lost; the thumb, being in a state of repose in adduction, could not reach the hollow of the hand. Sometimes a single finger is paralyzed; if it is the middle or ring finger, the movement of extension is often found completely destroyed, and the finger much bent upon the metacarpus; the fasciculus of the common extensor which passes to these fingers is alone deprived of contractility.

When the first and little fingers are affected, the movement of extension is generally incomplete, and the finger slightly bent: there is paralysis of the proper extensor only, or of the fasciculus of the common extensor, which is distributed to these fingers.

In the case of complete paralysis of the extension of the first or of the little fingers, the proper extensor, and the portion of the common extensor which belongs to these fingers, are found equally powerless, and the finger is much bent, without the power of extension.

In general, in the paralysis of a single finger, the permanent flexion is not as marked as in the case of paralysis of all the fingers; in fact, the diseased finger is a little relieved by that portion of the common extensor remaining healthy.

To refer paralysis to such or such a muscle, or to this or that fascicle of muscles deprived of contractility, some attention must be given to the examination of the facts. Thus, when the two middle fingers have lost only the motion of extension, and they are found in forced flexion, their weight draws with them in this last position the first and little finger, although these are not affected with paralysis.

To have positive proof that they have preserved all the extent of their movement, it is sufficient to sustain the middle fingers in a position between flexion and extension, so that the first and little fingers may reach the highest degree of the movement of extension.

In no case has paralysis been limited to the thumb; and sometimes it preserves alone, all its motions; sometimes the fingers are unequally paralyzed; there have been cases where the first finger was very little, while the others were considerably bent in a permanent manner. The loss of the motion of extension, adduction, and abduction, or of separation, is in proportion to their flexion. Cases have been observed where the paralyzed fingers assumed that very gradual flexion, from the first to the fourth, which characterizes a state of health.

A painter of buildings was brought to the Hospital of Charity, who had been attacked three months previous with a variety of paralysis of the fingers, not before met with. The right hand only was affected. Extension, adduction and abduction of the wrist and fingers, also the opposition of the thumb and little finger were perfectly well preserved. If the patient attempted to close his hand, the first phalanges easily bent upon the metacarpus; the second phalanges inclined still more upon the first, although with much difficulty and incompletely; in short, the third phalanges were immovable upon the second, and were constantly in extension, and the hand could be only half closed. The trembling of the flexors of the right forearm was much less powerful than that of the left.

The patient seemed therefore to be affected with paralysis of the deep seated flexor, with perhaps a slight touch of the same in the superficial flexor of the fingers, and possibly in the lumbricales.

Can this case of paralysis be attributed to any other cause than the man's trade?

Certainly not; when it is known that it attacked him after

lead colic, and there were no morbid phenomena in the head and spine which revealed an organic lesion of the nervous centres.

Nor can the paralysis be explained from a wound received more than thirty years previous, and which, having been healed, had never caused any inconvenience.

It is more difficult to explain the paralysis of the fingers than any other of the varieties here mentioned by the lesion of the nervous threads, which are distributed only to the paralyzed parts; in fact, these threads proceed from branches which send others into the parts exempt from paralysis.*

PARALYSIS OF THE INFERIOR LIMBS.

Lead paralysis of the lower limbs is much more rare than that of the upper. It has fixed the attention of authors much less than the last. Some have denied its existence, and others have said but a few words on it without entering into any detail.

In fifteen cases of paralysis of the lower limbs, the loss of motion was seated only four times in the right, three times in the left, and eight times in both limbs.

Among ten patients, paralysis of the inferior existed in connection with that of the superior extremities.

In five cases only, the loss of motion was in the inferior limbs, the superior preserving all their motions.

Lead paralysis of the abdominal extremities offers a series of varieties analogous to those of the superior limbs.

1. *General Paralysis of the Inferior Limbs.*

The patient cannot, by the help of the thigh, leg or foot, execute the lead motion; he is obliged to remain continually upon the bed, or arm-chair. The muscles of the limb are powerless in spite of every effort.

The only indication of contractility to be observed, is in an agitation of the muscles of the buttock and hip. The diseased

* The use of water transmitted through lead pipe gave the first unequivocal evidence of its poisonous effects in partial paralysis of the little and ring fingers of a gentleman of Lowell, in whose family the water was used. The case was well marked, and decidedly produced by lead water. The pipe was at once removed, and the paralysis gradually, but very slowly disappeared. Doubtless, had the use of the water been continued, general paralysis of the limb would have ensued. — S. L. D.

parts are wasted with surprising rapidity, and to an extreme degree.

At the end of a month, the distinct outline of the muscles is entirely effaced, the fat absorbed or softened, the skin loose and flabby.

Can the seat and extent of paralysis be here explained, by a lesion of the crural, popliteal and sciatic nerves, which are distributed to the parts deprived of motion?

In this, as in all the other varieties of paralysis, there have never been observed dull pains along the vertebral column before the attack; concomitant paralysis of the bladder or of the rectum has not been met with.

2. Paralysis of the Thigh.

The leg which is found half bent upon the thigh has lost its movement of extension.

There is paralysis of the triceps, and anterior crural muscles, and, consequently, permanent contraction of their antagonists, the biceps, &c. The leg, although able to bend more, cannot perform complete flexion, because the paralyzed muscles cannot elongate themselves sufficiently to obey the movement of the flexors.

The patient, when recumbent, mechanically stretches his leg upon the bed, but he cannot raise it in extension. He can stand in one place, though in a tottering manner; he can even walk, but it is with pain and difficulty; he drags along his foot upon the earth; the least inequality becomes an obstacle, and he easily falls. He finds much difficulty in descending stairs, but less in mounting. In descending stairs, the diseased person bends his leg upon the thigh as little as possible, and suddenly throws out the leg into incomplete extension, by moving the whole of the limb and ceasing to contract its flexors actively.

In ascending a staircase, on the contrary, the paralyzed leg has no need to strive with so much force against the movement of flexion; consequently a fall is not so imminent. When the patient is on his knees, he cannot rise without assistance, because the movement of extension of the leg upon the thigh, which contributes so much to the action of rising from the knees, is lost. When the patient is fatigued with prolonged

walking or standing, the feeling of weariness is especially felt in the knees. The anterior part of the thigh is reduced to a remarkable state of atrophy.

The paralyzed muscles, triceps and crural anteriors receive their nerves from the crural, which sends many branches to other muscles in their normal state.

3. Paralysis of the Thigh, Leg and Foot.

The leg, constantly half bent, cannot accomplish the slightest movement of extension upon the thigh; its movement of flexion, although preserved, cannot, however, be performed so completely.

Let the leg be bent as much as possible, as soon as the will of the patient ceases to contract actively the flexors, the leg returns mechanically to half flexion; the thigh itself is found a little bent upon the pelvis, but this effect is owing to the position of the leg.

The foot is maintained constantly in extension upon the leg; it has completely lost its movement of flexion. Situated in a position between adduction and abduction, the will of the patient cannot direct it alternately in these two positions. The toes are much bent upon the sole of the foot; their movement of extension and separation is wholly lost. A bony projection may be observed in the middle part of the tarso-metatarsal region.

Evidently, in this variety, are found united paralysis of the triceps, anterior crural, anterior tibial and peroneal muscles, and extensors of the toes.

The disturbance of the muscular equilibrium, determines an habitual predominance of contraction of the healthy and antagonist muscles.

Standing is impossible; if the patient wishes to turn round, the thigh is bent upon the leg, the leg upon the foot, and a fall is the consequence. With much more reason, walking is impossible.

But when lying down, he can execute movements varying from right to left, and in direction of flexion, with the whole of his limb; but it is impossible for him to raise and maintain it above the bed, since all the extensors which perform this general motion are deprived of contractility.

Some weeks after the attack of paralysis, the anterior region

of the thigh is flattened, pressed down as if glued to the thigh bone; the anterior tibial region participates in this wasting, but in a less sensible manner.

Some nervous threads of the crural, the anterior branch of the external popliteal nerve, and some particular branches of the internal popliteal are distributed to the paralyzed muscles; but all these nerves send also other threads and nervous branches to some muscles of the limb which are not paralyzed.

It is then difficult to refer the extent of muscular atony to a circumscribed lesion of the nervous trunks.

4. Paralysis of the Foot.

The toes are much bent upon the sole of the foot, in consequence of the paralysis of the extensors of the toes, and of the permanent contraction of their antagonists, the flexors. They can neither separate from, or approach, each other. The foot cannot be bent upon the leg; it cannot be brought into abduction or adduction in the direction of flexion. Thus, besides paralysis of the common extensor of the toes, and proper extensor of the large toe, the inter-osseous, anterior tibial and peroneal muscles are all paralyzed. All the other movements of the foot and leg are free. The point of the foot is directed downward and forward, the sole is concave; this unfortunate position is a great obstacle to walking and standing.

When the patient walks, he raises and throws out his feet in extension, like inert masses. It is the pressure on the sole, which, in a mechanical manner, produces flexion, when he turns round or walks.

One case has been observed, where paralysis was limited to the proper extensor of the great toe.

All the above varieties of paralysis may be combined two and two, three and three, or even four and four, in the same individual.

It is rare to meet in one patient the same variety, or the same degree of paralysis; either in the two superior, or the two inferior, limbs.

HEMIPLEGY.

Stoll and M. Andral have seen lead hemiplegy.

If, under this name, is comprehended partial or general pa-

ralysis of a superior limb, accompanied with partial or general paralysis of the corresponding inferior limb, then Tanquerel also has seen a case of lead hemiplegy, in a paralysis of the wrist and fingers of the left hand, with paralysis of the thigh on the same side.

PARALYSIS OF THE TRUNK.

Paralysis of the pectoral and grand dorsal muscles has already been pointed out.

A case has been noticed where the head was always directed to the right; evidently paralysis of the sterno-cleido-mastoid muscle of the left side.

Paralysis of the Breast, or of the Intercostal Muscles.

This lead paralysis, as well as that of the trunk, has not been pointed out by authors.

It is, in truth, very rare; Tanquerel mentions that he met with only two cases. The following are the signs by which it may be known.

Without previous physical lesion of the interior organs of the breast, an individual affected with colic or with lead paralysis of the limbs, is suddenly seized with great and difficult execution of the costal respiration; the sides appear almost entirely immovable.

When the patient is desired to make a greater effort of inspiration, the clavicles are manifestly raised, the thoracic parietes follow this movement of totality, but the sides can neither elevate or expand themselves.

The thoracic parietes are considerably weighed down; the action of the diaphragm, on the contrary, is highly increased, and in its alternate contractions causes the stomach to bulge in an extraordinary manner; respiration becomes noisy, and expectoration difficult; the secreted liquids accumulate in the lungs, become frothy, and oppose the entrance of air; congestion of the lungs takes place, and death soon follows. It is death by asphyxy analogous to that of animals, whose pneumo-gastric nerve is divided, surviving the operation for a few days, and then succumbing to choking of the lungs. During all this scene, the pulse is irregular, very frequent and extremely small; the

skin is fresh, the face anxious, the eyes staring wide open, and the nostrils distended. The understanding is clear, speech short, quick, and aphonous; the other functions do not experience any remarkable change.

It would be easy to explain the seat of this paralysis by a lesion limited to the intercostal nerves, or to the dorsal portion of the spinal marrow, corresponding to the intercostal muscles.

PARALYSIS OF THE VOCAL MUSCLES.

Baglivi, Citois, Dehaen, Bonté, Desbois (de Rochfort,) &c., speak in a general manner of aphony which may take place during the course of lead colic.

Lead emanations may exert their deleterious influence,

1st. Upon the muscles which produce the voice, and cause a difficulty in pronunciation.

2d. Upon the larynx, and cause aphony.

1. Among the individuals in contact with lead preparations, and most often attacked with lead colic or with lead paralysis of the limbs, sometimes the lips and the tongue only are affected with trembling. The different movements of the parts are not entirely destroyed, but they are no longer executed with regularity and facility; their extent is limited.

Their principal functions are also executed in an incomplete and irregular manner. Thus, the patients experience the greatest difficulty in forming sounds; the words are pronounced incompletely, and with agitation; there is stuttering and slaving.

The drinking vessel is seized with hesitation and difficulty; the action of drinking is also irregular and uncertain. Tanquerel has met with no cases of lead paralysis of the pharynx and œsophagus; if the drink once reaches the throat it easily finds its way to the stomach. A complete paralysis of the lips and tongue has not been observed.

2. The organ of the voice, especially, may feel the deleterious influence of lead. Then aphony occurs, which can be attributed only to paralysis of the proper muscles of the larynx.

3. Lead paralysis of the muscles of speech and voice may be concomitant. It is impossible to say if one muscle of the larynx, of the tongue, or of the lips is more paralyzed than another; or to analyze the different movements of the vocal apparatus, so as

to indicate precisely the diseased muscle. It must necessarily be admitted that one muscle of these organs is as much enfeebled as another.

The hypoglossal nerve is the motive nerve of the tongue, while the recurrences and the superior and inferior laryngeal branches of the pneumo-gastric nerve are distributed to the muscles of the larynx. Will the direct lesion of the vocal nerves explain the difficulty of pronunciation, and the aphony caused by lead?

CHAPTER V.

PROGRESS, DURATION, AND TERMINATION.

THE progress of lead paralysis is in general slow and gradual, requiring from a few hours to fifteen days for development. The symptoms, after increasing for a certain time, remain stationary for a longer or a shorter period, according to the mode of treatment employed; then they diminish by degrees; so that the passage from health to sickness, like that from sickness to health, is nearly insensible. In this respect lead paralysis should be classed among chronic diseases. Paralysis, during its progress, may be combined in many different ways with lead colic.

The most common case is that in which colic comes on by degrees, and paralysis as insensibly; as soon as one of these diseases is more apparent, the other disappears. It seems a metastasis of morbid matter from the abdomen to the limbs. In other circumstances, the attack of colic and paralysis is simultaneous, and each continues its progress as if it existed alone; the symptoms of one increase and diminish with the symptoms of the other. In short, paralysis may rarely attack a person in the midst of violent colic, which suddenly ceases; or at least violent intestinal pains are much calmed, and finally disappear.

When patients, who have not been completely cured of lead paralysis, and whose limbs perform their functions imperfectly,

are taken again with lead colic, their paralysis usually increases with every new attack of this disease.

It has been already remarked, that lead paralysis could not co-exist with colic, except in certain cases where it preceded all other lead disease, or where it was manifested when all the symptoms of colic had disappeared. Often when paralysis of motion is evident in some points, for example, where it is most usual in the upper limbs, neuralgic pains occupy the lower. Sometimes the two lead diseases, paralysis and arthralgy, simultaneously appear in the same parts.

The first of them may be preceded or followed by the other. Arthralgy does not last nearly so long as paralysis.

It is the want of knowledge of these two distinct forms of disease, as well as of their accustomed seat, that has made authors believe that paralysis was frequently preceded by pain. Arthralgic pains rarely precede the attack of paralysis in the same region; usually when these two affections begin, or progress together, they occupy different parts.

Sometimes, however, the increase of sensibility produced by lead, precedes the loss of motion of the parts affected with paralysis. Trembling usually takes place at the commencement or close of the disease; it may be the only symptom of paralysis of motion. When paralysis affects the whole of one limb, it usually commences in the upper parts; the inferior are attacked last; for example, in general paralysis of the upper limbs, the muscles of the shoulder, then those of the arm, of the forearm and of the hand are successively struck with atony.

In paralysis of the lower limbs, the muscles of the thigh first, then those of the leg, of the foot and of the toes, lose the power of contraction.

The disease follows the same order when it is near the cure; that is, first the shoulders, then the elbows, and at last the wrists and fingers recover; but paralysis of the deltoid often remains after the cure of all the other muscles. The fingers often resume their office before the wrists, but the contrary frequently takes place. In the case of general paralysis of the upper limbs, the cure always commences in the flexors, then in the pronators, then in the supinators. The extensors are always the last to resume their motion, as they are nearly always the first attacked.

In the inferior limbs, the cure commences in the thigh, then in the leg, lastly in the foot.

The appearance and disappearance of paralysis in different parts of a limb, may take place at intervals more or less distant. It rarely attacks all of one limb at once. When it attacks both upper and lower limbs, it usually begins in the lower, which also are the first to recover. Commonly, one of the limbs is affected with paralysis before the same paralytic phenomena are developed in its correspondent. In the paralysis of the forearm, wrist and fingers, the disease begins very often in the common extensor, then in the proper extensor, and so on, in such a manner, that it is the middle and ring fingers which appear first paralyzed.

Paralysis of the vocal apparatus is concomitant only with that of the limbs, and follows generally the same progress. Paralysis of the intercostal muscles quickly puts an end to existence. The two patients in whom it was observed were also affected with partial paralysis of the superior limbs.

Lead paralysis may last for some days or years, or even the whole life of the patient.

Its duration is influenced by the time which has elapsed since its onset, by the extent of the disease itself, by the mode of treatment employed, and by the age and constitution of the patient.

The more recent the disease, the more easily is it cured. Formerly physicians regarded all lead paralysis as incurable which did not yield to the treatment of lead colic. Some, however, as Dehaen, Stoll, Bonté, and Gardane, had faith in sulphur baths and electricity. At the present day this opinion is not held, and all lead paralysis, of however long standing, is susceptible of cure, provided the paralyzed muscles are not totally wasted or transformed into cellular tissue.

General paralysis of a limb requires longer treatment than that of a single muscle; whilst energetic treatment is most successful, it must be allowed that this disease yields only to a patient and long continued curative course, and that it may continue during the greater part of life. Musgrave cites a case which yielded not till after ten years' treatment. Recovery is more certain if the disease is attended to at the first attack. When paralysis has attacked the same parts a number of times the cure is more difficult.

A young person will be much more easily cured than one advanced in age, and a good constitution stands a more favorable chance of a speedy cure than a weak one.

Lead paralysis terminates in health, death, or change to another disease. The first mentioned termination never takes

place in a rapid manner; when a feeling of nimbleness is perceived by the patient, then the disease progresses more rapidly towards a close. It is surprising to see at this moment with what rapidity the muscles resume their volume; they almost seem to grow; the cellular tissue is repaired with quite as extraordinary a rapidity. The whole system which had shared the languid state of a part of the limbs is soon revived. The skin becomes ruddy, the face recovers its embonpoint, and exhibits the blush of health.

The regularity and assurance of the movements of the limbs and trunk, the full respiration, the force of the pulse, the increased degree of heat, the solidity of the flesh, a sensible diminution of the excretions, all announce that nature has at length resumed her rights, and the disease has at length disappeared.

At the same time the articulations, which have been a long time immovable, make a little grating in their motions; a noise which announces, certainly, a defect of synovia; the limbs ought then to be made to execute every variety of movement to correct and destroy the dryness of the articulations. Sometimes the disease may be cured by nature alone, but this is rarely the case.

Winter is not a favorable season for the cure of this disease; spring promotes recovery, and some cases of unfortunate workmen, deprived of all assistance, languishing five or six months with paralysis, have been cured by the influence of this beautiful season, without any other remedy. It is very rarely that lead paralysis alone will cause death; this termination is usually the result of paralysis of the intercostal muscles; most commonly it is owing to complications of diseases unconnected with lead.

CHAPTER VI.

DIAGNOSIS AND PROGNOSIS.

THE diagnosis of lead paralysis is in general easily established. In fact, who could confound it with any other form of paralysis, when the trade of the diseased person is known, when it is known if he has been exposed to lead emanations, or if he has used internally or externally any lead preparations, or if he has been attacked with colic?

These antecedents, joined to the seat of the disease, to the common partial lesion of the muscular system, and especially of the extensors of the limbs, to the preservation of sensibility in the diseased parts, to the progress and first appearance of the disease; in short, to the absence of phenomena, which denote a lesion of the spinal marrow or of the brain, establish a sensible difference between this and all other paralyses.

There are cases, however, in which the diagnosis of this specific paralysis is difficult to establish, in consequence of the obscurity which may rest upon its origin. It is then necessary to know if lead paralysis can be recognised by its appearance alone, independently of antecedents connected with the trade of the patient.

Tanquerel has met with one case of loss of motion of the extension of the wrist and fingers, accompanied with anæsthesia resembling lead paralysis, but unconnected with exposure to lead preparations.

This disease attacked a tailor, who, after drinking, stretched himself upon the grass in the shade from four o'clock till ten in the evening, in the month of July. Upon waking he perceived he could no longer extend his wrist and fingers. On the first examination of the disease it was thought to be lead paralysis, and yet, after minute questioning and scrutinizing for a month, it was ascertained that he had never been in any circumstances where he could contract a lead disease.

In this case the antecedents can alone raise doubts of the diagnosis. Authors who have written upon the colics of Poitou, of Madrid, of Devonshire, speak of partial paralyses of the extensors of the limbs, which take place during the course of these diseases.

But if these colics are not due to a lead poison, it is not easy to distinguish these paralyses from those produced by lead, except by a knowledge of the cause which has existed at their development.

But all which has been printed upon the colics of Poitou, Madrid, and Devonshire is so vague and so little precise, that there can be little belief in the existence of the partial paralyses which accompany those diseases, belonging to the country where they are developed.

A case has been observed of paralysis of the extensors of the toes, following typhoid fever.

The nature of the disease preceding the attack of paralysis could alone prevent the reference of this loss of motion to lead.

These partial paralyses are sometimes met with, succeeding rheumatism, and especially gout; but in these cases, the loss of motion is felt indistinctly in all the muscles of the diseased limb, and the flexors as well as the extensors are equally paralyzed.

Tumors upon the course of the nerves or muscles of a limb, sometimes occasion paralysis of the motion of all the parts situated beneath, but in these cases, the evident cause of the disease is sufficient to establish the diagnostic. In fine, sometimes, a partial paralysis of the limbs, very like that caused by lead, occurs independently of a material lesion of the nervous centres.

The different circumstances in which the loss of motion has appeared, can alone then serve to establish the diagnostic.

PROGNOSIS.

Paralysis is one of the gravest diseases caused by lead; its consequences should always cause it to be regarded as a formidable affection; for it usually deprives the unfortunate persons who are attacked with it of the means of earning a subsistence. Sometimes its prognosis varies according to the degree, extent, and age of the disease, the importance of the affected organs, and the age and constitution of the individual. Prognosis is favorable in proportion to the loss of contractility; when there no longer exists any trace of this property in the affected part, there is little hope of success. The greater the extent and age of the paralysis, the more difficult is it to cure; the prognosis also is much more unfavorable in general paralysis of the limbs which lasts for some months, or years, than in that which is limited to a small number of muscles, and which dates back only a few days.

The influence of the first will be felt upon the rest of the system, the recovery will be difficult and slow; while the influence of the second will, generally, be limited to the place where it first appeared, and will yield easily and quickly to well directed treatment.

The more important the functions exercised by a paralyzed organ for the preservation of life, the more dangerous is the disease; thus paralysis of the abdominal members is infinitely graver than that of the thoracic.

Paralysis of the intercostal muscles is, and must always be, mortal; whilst that of the limbs will last as long as life, without causing the death of the subject. Aphony, or even the loss of speech, are not accidents which should cause much uneasiness; they usually follow the progress of paralysis of the limbs, the prognosis of which they do not influence. All other things equal, youth is considered a better augury for the cure than old age. When the constitution is strong and little changed, the efforts of nature, combined with a proper treatment, may be relied upon. But if paralysis has reacted upon the entire constitution, deteriorated it, and reduced it to the state of inertia in which all parts of the system seem to vegetate, then there is no more hope of cure. As long as paralysis is limited to some muscles of the limbs, the prognosis is favorable, especially if prompt and appropriate measures have been or may be used. Tanquerel has known only two fatal cases of lead paralysis. In these, death was caused by paralysis of the intercostal muscles. In all the other cases, death has been the result of concomitant lead arthralgy, colic, or encephalopathy.

CHAPTER VII.

ANATOMICAL ALTERATIONS.

Seat and Nature.

It is to be regretted, that so little is known of the pathological anatomy of lead paralysis. Attempts, however, have been made to discover the anatomical lesion of this affection. From these researches there follow no conclusions, or from them have been drawn wrong deductions. Perhaps, because their authors have described them imperfectly, or have considered as belonging to lead paralysis some anatomical lesions, which were the result of accidental combinations. Astruc, Lepois and Willis refer this paralysis to lesion of the brain and spinal marrow, but they have demonstrated nothing by dissection.

The appearance of the brain and spinal marrow described by

Dr. George Kiston, (*Lond. Med. and Surg. Journal*, 1828,) on the autopsy of a singular case, may be referred either to the disease of the brain which appeared at the *close* of the lead malady, or it may be an accident due to cadaveric imbibition. So also the two cases reported by Andral in his "Clinique" show, that the supposed causes of lead paralysis derive no support from lesions and alterations which could be detected on autopsy, by this great master in pathological anatomy.

In 1833, two patients who had lead paralysis died at the Hospital of Charity. Autopsy of these subjects was performed with rigid exactness, with all the skill and science of distinguished professors; and again Tanquerel, still later, examined four other subjects, who during life had suffered lead paralysis. In all the cases there were lesions concomitant with lead paralysis, but no evidence of anatomical alteration, which could account for the phenomena of the disease. No change was observed, which is not common to other forms of long continued paralysis. Nor could the acute Dr. Gluck discover by microscopical examination, any change in the structure of the spinal marrow, nerves or muscles.*

* Rumpelt, in his work on the effects of lead, &c., institutes the following comparison between his observations and those of Tanquerel; the last are on a great number of brains.

RUMPELT.

1. The gray and white substances were not to be readily distinguished, both of a gray white.
2. By slight traction, some portions were easily separated, which presented an evident fibrous appearance.
3. Brain of an adult forty-eight hours after death; both substances of brain were easily distinguished, notwithstanding a substance similar to white.
4. Substance of brain of dense consistence and easily broken.
5. Pia mater was thickened and easily separated.

TANQUEREL.

1. *a.* Substance of brain, externally a dirty yellow, internally grayish; the gray substance of an ash gray yellow. *b.* Substance of brain of a dirty yellow.
2. Dr. Gluck noticed a number of canals through many parts of the brain, in a lead subject; these he considered as morbid appearances.
3. *a.* Substance of brain of a yellow color. *b.* The white substance was a dirty yellow, ash gray and dull, and almost transparent. Gray substance was yellowish green.
4. *a.* Parenchyma of brain was hard. *b.* Broke easily like liver. *c.* Convolutions flattened; depressions between them disappeared. *d.* Texture of brain hardened.
5. *a.* Meninges dry. *b.* Ibid. *c.* Meninges of an encephalopathic subject dry. *d.* Meninges with their distended blood-vessels were dry.

See *Amer. Jour. Med. Sciences*, 1846.—
S. L. D.

It is difficult to point out exactly the seat and nature of a disease, when deprived of the light of pathological anatomy. Here, as in all purely nervous diseases, which leave no traces in the parts where they had their seat, pathological anatomy at least shows that this disease ought not to be attributed to organic lesions.

On the other hand, death being due in the greater part of cases only to complications, the cadaveric lesions, far from throwing any light upon the seat of this paralysis, embarrass it the more.

Thus, to decide such a question, it would be necessary to refer to physiological inductions, and, unfortunately, these are to be received cautiously, in consequence of the uncertainty upon which they are sometimes founded. It is then with the diffidence that these considerations demand, that what relates to the seat and nature of this disease will be explained. Omitting the opinions of Boerhaave, Baglivi, and even Citois, the ingenious theories of Astruc and Bordeau, and other writers of a by-gone age, we find among modern physicians few who have dared to pronounce upon the seat of this paralysis. Broussais and Ranque speak very simply of the seat of it; saying that it is the result of the sympathetic action of the colic upon the limbs, thus bringing forward the stale opinion of the ancients.

That would be a singular malady which should determine by sympathy another disease precisely at the moment of its disappearance. The second disorder existing then alone, by virtue of what consent would it continue to exist? By what sympathy would the primitive paralysis be produced? This opinion does not repose then upon any foundation.

Each muscular fibre possesses the power of contracting by the fluid that the nerves transmit to it. The seat of the disease must then be sought in the nervous system.

Magendie, Flourens, Calmeil, Ollivier (d'Angers), Bellingieri, all agree in declaring, after numerous experiments, and accurate observation of the facts of pathological anatomy, that there exist in the spinal marrow two distinct parts, endowed, one with the power of transmitting motion, the other, feeling.

This beautiful discovery is admirably confirmed by the stupefying action of lead upon the spinal nervous system; since this poison attacks sometimes the parts which preside over motion, sometimes those which govern feeling.

It might be objected that partial lead paralysis cannot depend

upon a direct lesion of the spinal marrow, for on the one hand there are no morbid phenomena about the spinal nervous centre; while on the other, it is contrary to reason to admit that a central lesion of this nervous system can cause an effect at the lower extremity of a nerve, while the space between the seat of the affection and of the diseased nerve is sound, and consequently throughout this space performs its healthy functions. To this objection it may be replied, that narcotics act on the great nervous centres, and yet sometimes these show their paralyzing effects only in the lower limbs.

Strychnine in a large dose acts on the spinal marrow solely; yet there is neither pain nor twitching along the spine; it is only at the extremity of the limbs that physiological phenomena occur.

Symptoms then which betray lesion of the spinal marrow are not exhibited about that organ itself, or along the parts to which it sends the power of motion.

Thus the conclusion is fair, that some part of the spinal nervous centre is altered in lead paralysis. The affection can be revealed not by anatomy, but by the symptoms only. It is as impossible to say how lead acts in this case, as it is to account for the effects produced by strychnine.

It may be added, that allowing this opinion of a change in the nervous centre, effected by lead, to be correct, the whole history of lead paralysis places it among nervous diseases caused by lead, and ranks it as a case of narcotic poisoning.

CHAPTER VIII.

TREATMENT.

THE treatment of lead paralysis has for a long time occupied the attention of practitioners; the most diverse opinions have also been admitted on the subject.

Physicians, who, like Astruc and Bordeu, believe that paralysis was due to the obstruction and compression of the origin of the nerves, think best to combat it by antiphlogistics and bleeding

principally. This is a dangerous opinion. All other observers, though differing about the kind of treatment to be employed, are, however, agreed upon this point — that the whole attention of the physician should be directed to one object, to excite by every possible means animal contractility in the paralyzed muscles.

Some have had recourse to excitants of all kinds, tonics, and, among them, ferruginous mineral waters, and preparations of bark, have been used in that state of cachexy, which lead paralysis sometimes determines, with the intention of bringing on an active, general circulation, and assisting it in the paralyzed parts. Stoll prescribed with some success stimulants, such as ammonia, camphorated alcohol, oil of sweet almonds with tincture of cantharides, oil of rosemary, henbane, or nutmeg, &c. But the stupefying properties of these medicines and their action upon the brain should cause them to be rejected; they are admissible in frictions, which usually produce imperceptible effects. The preference for this purpose should be given to rubefacients and sinapisms, the good effects of which Stoll himself has praised.

What shall be thought of the use of sudorifics as a cure for this malady? Can these determine by sweat the excretion of the poison supposed to be lurking in the system? Vesicatories applied in great number to the diseased parts, or to the neighborhood of the nervous plexus, moxa, placed upon the side of the vertebral column, have seemed to produce some relief, and sometimes, though rarely, almost complete cures; but in these cases, it is necessary that the disease should be of small extent, and that the paralyzed part should not be entirely deprived of motion.

Huxham, Astruc, Dehaen, and some other physicians, have extolled, without drawing great advantages from it, the use of dry friction on the length of the vertebral column, in the armpits, the groin, and the paralyzed parts. The treatment at the "Charity" for lead colic, or any of its analogues, is generally directed to recent and incomplete paralysis. Tanquerel has seen this means decidedly efficacious but once. It is best to combine dry friction with the other existing modes.

Foville is said to have given turpentine with marked success in cases of paralysis produced by emanations of the preparations of lead. (*Dict. de Méd. et de Surg. prat.* tom. xii.) Tanquerel has not been so successful as Foville; in five cases of partial and very recent paralysis, where this treatment was adopted, there followed no sensible change in the diseased parts.

Douches, by the vivid and instantaneous percussion that they produce upon the paralyzed parts, determine there an excitation favorable to cure. But all these means are insufficient for the perfect cure of lead paralysis; it is necessary to have recourse to more energetic measures. Bonté and Merat value the salutary effects of sulphurous mineral waters, and nearly all physicians agree at the present day in extolling this treatment by baths and drinks. Electricity, first used for paralysis by Dehaen, was employed with more or less success by the Abbe de Sans, Bertholon de Saint-Lazare, and others. In later times, Fouquier and Rayer have drawn from it great advantages.

In short, Fouquier employed first with success the different preparations of nux vomica, and especially its alcoholic extract in lead paralysis; still later, Bally, Rayer, Lemberg and Andral have tried with much advantage the use of strychnine.

These three last modes of treatment, of which Tanquerel has made a special study, will now be particularly detailed.

Sulphurous Baths.

Bonté strongly advises this remedy in lead paralysis; the sulphurous thermal waters, according to him, are still more efficacious.

Merat cites numerous cures obtained by sulphurous baths among painters. Success has even been so great, that patients just attacked with this disease are sent from the port of Ferrol to a neighboring stream, where it seems as if they are cured by enchantment, without the aid of other medicines.

Merat relates this wonderful fact, but it should be verified before full confidence can be given to it.

Sulphur baths are generally employed in paralysis. To produce effect, they ought to be much charged with medicated substances; five or six ounces of sulphuret of potassium should be put into a bath which should be lukewarm only; the patient should remain there from one hour to three quarters of an hour.

During this time he experiences nothing unusual, except a feeling of general heat.

In leaving the bath, it seems to him that his limbs are lighter, more supple, easier to move; sometimes he is taken with deafness, with fainting, or acute cephalalgia.

A general redness is remarked upon the whole surface of the

body, and principally upon the diseased parts, which are often covered with a black matter more or less abundant; which is nothing more than sulphuret of lead, produced by the decomposition of the sulphuret of potassium of the bath by the lead concealed in the pores of the skin.

Must it be said, then, with some authors, that from this fact, sulphurous waters neutralize the effects of lead applied to the skin, giving rise to a chemical compound, insoluble in water and consequently absorbed more slowly?

A quarter, or half an hour after leaving the bath, the patient feels his limbs, which were stiff, become heavy and awkward in motion; at the end of two or three hours he perceives that his movements are more regular, that they acquire force and assurance. Sulphur baths exhaust the patient, at length, by the abundant perspirations that they induce, as well as by the itchings, followed by little cutaneous eruptions which come out every where; so that it is not necessary to continue them for a long time. Lead paralysis has been cured by using this treatment only five times. In each case so cured, paralysis was incomplete, and limited to some muscles.

The little energy of these remedies, would necessarily make them useless in complete and extensive paralysis. Sulphur baths ought to be employed in a continued manner, when already, by means of electricity or of preparations of nux vomica, an excitation capable of arousing the vital powers in the muscles is produced. Then these baths strengthen and give tone to the still feeble parts, and they often calm the too violent effects produced by these energetic medicines; in these circumstances they succeed perfectly well.

Electricity.

Electricity having been for nearly a century employed in paralysis, the manner of using this remedy, and the therapeutic results obtained, have necessarily varied. Thus Dehaen and Stoll could direct against the paralyzed parts only some electric sparks by means of the electric machine. Later, when the famous Galvani had discovered the fluid which bears his name, an attempt was made to stimulate the paralyzed parts by means of galvanic currents, obtained by the galvanic or voltaic pile. Gardane has employed galvanism with the greatest success in

lead paralysis; he also pronounces upon it the most pompous eulogy.

In later times, when physicians have had the idea of connecting electricity with acupuncture, they have caused the fluid to penetrate more deeply, and directed it more particularly upon certain parts, by sinking the needles there which serve for conductors.

It would be going beyond the limits of this subject, if the manner of applying the electric fluid to the paralyzed parts, by these three processes, should be described. When a part of the paralyzed body is presented to a conductor of the machine in motion, some sparks are produced which are felt in the point where they strike. A pain more or less lively, like a pinching, and to which is joined, if the apparatus is a large one, a painful shaking, produced by the sudden contraction of one or more fascicles of muscular fibres subjacent to the point struck by the spark. If the sparks follow quickly, the skin becomes painful, red, warm, and finally the seat of an inflammation which is extended in rays.

The galvanic current directed upon a part where motion is annihilated, produces the following effects.

The part which is found in immediate and prolonged contact with the conductors, experiences, at first, a painful sensation of heat, and soon becomes the seat of an inflammation which advances with rapidity even to gangrene.

The muscular parts feel sooner than the skin the influence of the galvanic fluid, or at least manifest it in a less equivocal manner, by contracting themselves with more or less energy and rapidity, according to the force of the apparatus which is used; then, the patient is aware of the action of the treatment by shakings and muscular contractions, which can be renewed at will. But however violent the action of galvanism may have been, once let it cease, and it leaves no immediate traces of its effects.

The phenomena of electro-puncture approach near those produced by the electric machine, and galvanic pile. The lightest detonations of electricity upon the needle introduced into the paralyzed tissues, occasion a sensation of vibration in all the suffering parts.

If this part be a muscle, it is felt and even seen contracting through the skin; the strongest discharges impress upon it a kind of convulsion, and it is in these shakings that the nerves of a painful part are found modified, and the pain unnatural.

The accidents that the electro-puncture may determine are the same as those of galvanism, but that produces oftener than this last means inflammation of the electrified parts. Galvanism provokes lively contractions, powerful sensations of pricking and burning in parts rendered insensible to sparks and electrical commotions by their diseased state; its effects are more constant, more sustained than those of the machine, they are also less influenced by atmospheric changes. The preference should be given to the employment of the galvanic pile or trough, rather than to an ordinary electrical machine.

The electro-puncture, acting in a more direct, more immediate manner, its effects penetrating and affecting the nervous and muscular organs more profoundly than the pile and electrical machine, ought to be preferred to all other modes of administering electricity.

Certain precautions ought to be used in the therapeutic attempts at electricity. Thus it is best to graduate the immediate effects, and proportion them to the strength of the individual generally, and the delicacy of the parts upon which the machine is to operate. It is on these principles that the number and length of the applications should be regulated. Experiment seems to prove, that it is best not to excite strong commotions, to limit them to light shocks, and especially to multiply the electrical currents. Care must be taken not to exhaust the patient by continuing too long the exercise of electricity. Under such circumstances, the remedy has been sometimes more hurtful than useful.

In the two last observations on lead paralysis, treated by electricity, that Sigault De Lafond relates, the patients have rather grown worse than better; and several other observations related by authors confirm this still more. It is necessary that the contact of the electric conductors should not be too much prolonged; for the skin being disorganized, the remedy would produce inflammation, vesication, and even mortification more or less extended.

These accidents excepted, the effects of electricity have been very marked; no trace of their action remains, even after muscular shakings, such as are produced by a strong dose of nuxvomica or strychnine.

The subjects of the experiments do not remember any impression that they received.

At all times the employment of electricity in lead paralysis has found warm advocates and powerful enemies. Whence arises this great difference of opinion?

On the one hand, in a great number of experiments that are related, an apparatus, imperfect, and of little power, was used, which renders useless the greater part of the observations.

After all, how few are capable of administering electricity! and those who do it without being familiar with the apparatus, without knowing from experience all the immediate effects, must see it in their hands, either remain useless or become dangerous.

How many presumptuous physicians, in these circumstances, have decided a question that they were not capable of solving!

The length of these experiments, before arriving at a perfect cure, discourages the experimenter. In a lead paralysis of the arm reported by Yantroostwyk, motion returned to the fingers, and the patient was not entirely cured till after two hundred and ten applications of electricity. He received at a sitting between eight hundred and a thousand little shocks.

On the other hand, a smaller number of experiments, made by capable and patient men, have been crowned with success. Hence—now successful, and now, no useful result being produced, a difference of opinion of its value has arisen—the employment of electricity should not be given up; it should be trusted to learned and able physicians, and the application of it varied, or continued with constancy.

This remedy is especially convenient in paralyses limited to a small number of muscles, because the electric stimulus may be carried to such or such a point, to be there sustained or increased, at will, or be suspended instantaneously, without the nearest parts suffering in the excitation. Fifteen of the patients affected with partial paralysis of the superior limbs, more or less ancient, have been treated by electro-puncture.

Eight have been completely cured after one month, five or six weeks, two months and a half, nine weeks, three months, and three months and eight days.

Among seven others there were developed inflammatory accidents, which prevented the continuance of this mode of treatment, or else the patients, exhausted with the pain they felt at the first sitting, have wished to give up this mode of treatment before the cure was perfected.

Strychnine.

Strychnine, an alkaloid, discovered by Pelletier and Caventou, in the bean of *St. Ignatius* and the *nux vomica*, may be administered to remove lead paralysis in two different ways, internally, or externally.

Pills should be preferred to the other preparations, because of the insolubility of this substance, and the greater facility of giving it in determined quantity; its effects are also more apparent under this pharmaceutic form. Each pill may be composed of from one eighth of a grain to two grains; pills may be taken at first in small doses, increased gradually every day until they produce the desired effect, when they may be left off to avoid accidents.

Sometimes the dose may be raised to a grain and a half, or two grains a day to produce the tetanic shakings; the dose may be continued in such a manner as to maintain and continue the commotions.

If there is any reason for interrupting the use of the remedy for several days, it is best to recommence with feeble doses, and increase them gradually.

When it is desired to produce slow effects from this substance, a sixth of a grain a day is a sufficient quantity.

Two or three hours generally elapse, after taking this medicine, before its operation commences. According as the dose is greater or less, the voluntary muscles are seized with a powerful and permanent contraction. This spasm, which the patients compare to a numbness, is developed in an imperceptible manner, and occurs at the same time in all the parts that it will effect; it soon increases, and often in a few minutes attains its utmost point of rigidity.

This state has all the characteristics of true tetanus. The greater part of those physicians who have written upon this subject, think and affirm, that strychnine may determine the spasmodic contraction of the paralyzed muscles without affecting the healthy parts; that taken in small doses it acts only upon the diseased parts.

This decided predilection, this sympathy of strychnine taken internally for the paralyzed muscles, has not been observed by Tanquerel in lead paralysis. The first doses of strychnine that

are given constantly, determine general spasmodic contractions, and in points often far distant from the paralyzed muscles.

Soon the prolonged use of strychnine directs and concentrates its effect upon the part nearest the seat of paralysis; finally, the paralyzed part becomes the most common point where the excitant phenomena of the vegetable alkaloid are manifested; then only do they progress rapidly towards a cure. Tanquerel has never observed that the diseased organs feel as much more vividly the action of this remedy, as they were before deprived of motion and feeling.

It is not probable, that the nature of the paralysis causes the seat of the action of strychnine to vary.

This remark is made, because authors have principally studied the effects of this alkaloid upon paralysis which was not caused by lead. Even in such cases, the effects are identical with those seen where lead paralysis exists.

It should be remarked here, that the physicians who have reported observations upon paralyzes cured by strychnine, have noticed, only at a greater or less interval, the effect of this alkaloid, and, consequently, they have been easily deceived.

Tanquerel has noticed very minutely, hour by hour, day by day, the phenomena produced by strychnine among the patients under its influence.

In general, the upper limbs are in a state of flexion, and the lower in extension, during the spasm produced by strychnine.

The artificial tetanus that paralytics experience, incommodes them generally so little, that the greater part can sleep while they are affected. But it always becomes painful during the exacerbations to which it is subject. These occur only in cases where the spasm reaches a certain degree; they consist of more violent contractions, and there are felt sudden and passing commotions, which are called shocks, and which are more or less frequent; they come suddenly and without apparent cause; or perhaps occasioned by some movement impressed upon the patient, or made by him, or even by aid of the lightest contact.

These exacerbations, which are proofs of the energy of the treatment, are also the forerunners of its curative action; and no marked advantage has been obtained, unless these phenomena had been observed, and lasted for some time.

Serres says, that sometimes, rarely however, there is noticed in the body a feeling of restriction and trembling following the

use of strychnine. This is considered as indicating the cure of the disease.

The symptoms just related do not always betray the effects produced by strychnine; sometimes, it is only a feeling of uncomfortable oppression, sudden and instantaneous starting, a sensation of great heat, or a considerable exaltation of sensibility in the diseased parts.

At other times, there are painful prickings, beatings, dartings, pullings, a kind of rending of the muscular tissue, a sort of cramp, in short, a feeling of compression which announces the secret and salutary action of strychnine.

The jaws become almost constantly the seat of a numbness, a very inconvenient and often painful constriction; they sometimes close convulsively; then is observed a grinding of the teeth, which alternates with the chattering of the jaws; the teeth themselves are often painful.

A stiffness which is an obstacle to motion is often felt in the nape of the neck.

Some patients complain of slight colic, which they compare to a bar extending from one hypochondrium to the other; others say that they experience a kind of twisting around the navel.

Very frequent gaping and stretching generally takes place, a cephalalgia, more or less acute, occupies all the circumference of the head, and is more particularly felt upon the upper part.

It is generally observed, that strychnine does not affect the energy of the stomach, but, on the contrary, excites the appetite and facilitates digestion; nevertheless, the alvine evacuations habitually become more rare. A sort of drunkenness often seizes some paralytics, which is accompanied by some somnolency.

The general perspiration, especially of the diseased parts, is usually increased.

The pulse is accelerated, heat and circulation are sensibly revived in the paralyzed parts. This substance produces much more frightful accidents when it is administered without rule or measure; when this alkaloid is given internally, the doses may be very much larger without their effects being seen.

But this apparent inaction should be suspected, for suddenly the storm will burst, and with such an intensity that the consequences of it can no longer be prevented.

Then terrible convulsions furrow the forehead, the occiput,

the vertebral column, the superior and inferior limbs, and the jaws.

The mouth is convulsively closed, and filled with foam. The teeth gnash forcibly, the patient bites his tongue, tosses himself in every way, rolls in his bed, and throws himself upon the floor. The limbs are twisted and stiff, the body bounds at the least shock, or the lightest contact. During the whole progress of this convulsion, respiration is suspended; the face becomes livid, and asphyxy is imminent; there is an entire loss of consciousness, and an abundant sweat bathes the whole body.

A calm, often deceitful, succeeds this convulsion, and the patient shows that he has all his senses; his respiration is accelerated; then by degrees it becomes slower; and from time to time lively contractions occur in all parts.

At length all ceases, and the patient feels as if his limbs were broken; he also experiences a feeling of painful weariness. It may also happen, when it is hoped the calm will continue, that there takes place a fit more violent and longer than the preceding one; all the parts of the face and mouth become violet, and are deformed by convulsive twitchings; the paroxysm returns, asphyxy is prolonged, and death is the inevitable consequence.

Post-mortem examination, even when the pains have lasted many hours, shows no traces of inflammation in the digestive canal; but the cerebro-spinal apparatus appears to be the seat of a serous accumulation.

These effects, whatever they may be, can be renewed at will by new doses of strychnine.

They are proportioned to the quality and quantity of this substance introduced into the alimentary canal during a certain time.

The degree and purity of the alkaloid causes its effects to vary in a prodigious manner.

There are some patients upon whom light doses always produce the above phenomena; others experience them after several successive doses.

It is thought, also, that the atmospherical constitution influences the effect of strychnine.

Thus when the day was hot and dry, or the weather a little stormy, the action of the medicine was very powerful; on the contrary, under the influence of a lower temperature, moist and cold, this action was less strong.

The patients seem much less susceptible to an artificial spasm,

as they experience it oftener; this is the reason why the physician is obliged to increase the dose of this medicine.

Lembert and Rayer first applied strychnine by friction, in lead paralysis; their efforts have generally been successful.

To obtain a successful result, great caution is necessary in the use of this method.

Experience teaches as follows upon this subject: it is necessary to commence by applying to the most fleshy portion of the paralyzed parts, a vesicatory, sprinkled with a large quantity of cantharides. The next day great care must be taken to raise up very exactly the epidermis and the false membranes which have been formed; then, upon the well denuded surface of the blister, very clear and very clean, let fall from a quarter of a grain to two grains of well pulverized strychnine. Re-cover the blister with blotting paper spread thinly with epispastic ointment.

At every dressing, the surface of the blister should be cleaned with much care, in such a manner that no false membrane may oppose itself to the absorption, and consequently to the action of this medicine.

Strychnine, well pulverized, quickly excites the excretories; it produces an abundant suppuration and numerous false membranes, soft, yellowish, formed by a plastic and coagulable lymph.

Vesication, treated as above, may last six or eight days; the action of the alkaloid is in general stronger in the first than in the last applications.

The application of strychnine upon a vesicated surface in good condition, determines a sensation of very painful burning one or two hours after other effects are manifested.

Then occur slight spasms, startings, movements of projection, and retraction of the limbs; gambols, partial, involuntary contractions, abrupt and passing commotions often preceded by numbness, pains, dartings, prickings, and vermicular motions in the limbs where the blister is placed, and particularly in the paralyzed parts.

Tanquerel wished to assure himself positively, if strychnine, employed by friction, caused its action to be felt upon the limb, or the parts of the limb most paralyzed; for this reason he has applied strychnine to vesicatories, placed sometimes upon the most, sometimes upon the least paralyzed limb; the influence of this alkaloid has always been greatest in the limb upon which there was no vesicatory, even though it might be less affected

than the first. The efforts of this medicine are limited almost entirely to exciting the paralyzed parts; nevertheless it is not rare for them to be found in the sound portions of the body.

Patients often treated in this way complain of cramp in the sound, and diseased limbs. For the rest, all the other considerations which have here been entered into upon the subject of strychnine taken internally, apply perfectly well to the use of this remedy by friction.

In whatever way strychnine has been introduced into the system, the movements it produces are more or less lasting; sometimes they cease at the end of a few hours, sometimes they last till the next day. Some paralytics experience effects from strychnine, and especially shakings, even though the remedy had been discontinued for several days.

When all the above phenomena are renewed during a certain time, the patient feels that his will resumes control over the paralyzed parts; sensibility and heat increase at the same time that the motions become less painful, limited, and uncertain.

But these happy results are a long time waited for; if excitation is too feeble, this treatment is unsuccessful. The remedy should act advantageously upon those patients attacked with lead paralysis, in whom the nervous system has lost only its activity, or has suffered a shock which has merely caused stupor.

These paralyzes may be cured by the use of stimulants; it is here then that strychnine acts in the most prompt and happy manner.

If it is considered how indirect, slow and uncertain is the action of other remedies employed in lead paralysis, it will be seen, that strychnine is without doubt the most energetic and safest of all.

Without speaking of the general means commonly used in lead paralysis, is it certain that guiacum, camphor, valerian and volatile oils have the property of increasing motion?

With more real efficacy, electricity merits a confidence it never will obtain.

Physicians, who have abandoned the use of this means to charlatans, and men ignorant of medicine, are blameworthy.

After all, is it possible to render common the therapeutic employment of this stimulant, which requires the employment of so many instruments, and so much precaution and care to act with safety? But this treatment should be preferred to the use of strychnine in some cases of lead paralysis. For example, if

the patient is affected with lead encephalopathy, it is better to have recourse to electricity, from fear of occasioning serious accidents, by again exciting the nervous centres with the alkalioid. Moreover, the employment of electricity is much less fearful for the physician, for in its gravest accidents, it does not produce phenomena as formidable as strychnine. The sulphur bath, a more easy and agreeable method than the preceding one, owes nearly all the favor which it enjoys to circumstances which are foreign to it, though specific virtues have been attributed to its use.

Strychnine has also over these methods the advantage of its easy administration; its action is besides more sure, prompt and powerful.

Tanquerel has never known this medicine completely fail in lead paralysis, unless the diseased muscles, reduced to the last state of atrophy, were transformed into cellular tissue.

In the employment of this medicine, all the prescribed rules should be observed with great exactness, to obtain marked success; that this has not been done, is the cause of the frequent failures of many practitioners. As to the administration of this medicine, the two modes spoken of in detail are good; and they should be combined or replaced alternately.

If, however, the patient has a weak constitution, and the stomach a little irritated, it would be better to try friction, which seems also to have a special salutary influence upon partial, whilst strychnine, taken internally, appears to act with more efficacy in general paralysis, for example, that of a whole limb.

These two modes of administering strychnine, have been crowned with the most brilliant success. Forty patients attended by Tanquerel have been under the influence of strychnine. Nearly all were completely cured; all, at least, were relieved in an extraordinary manner. The cure has occupied generally about two months. In eighteen cases, paralysis was limited to the wrist and fingers; in sixteen, it extended to the forearm and other parts of the superior limb; in six patients there was at the same time paralysis of the inferior limbs.

Four only of these patients have experienced no amelioration from the use of strychnine, or at least the result has not been remarkable.

Andral relates in his "Clinique" nine observations of lead paralysis, five of which were treated with strychnine taken

internally; three were cured, or at least diminished. Lember, in his memoir upon the friction method, cites three examples of lead paralysis of the wrist and fingers, of which the patients were entirely cured by strychnine administered by this means.

Brucine has been proposed by Andral for lead paralysis. Among four patients using this alkaloid, three have been remarkably relieved; one only experienced no amelioration.

The alcoholic extract of *nux vomica* has sometimes succeeded perfectly in the hands of Fouquier in lead paralysis. The effects of this medicine are nearly the same as those of strychnine; but less energetic, and less safe, from its variable degree of concentration. However the treatment may be employed, care must be taken to maintain frequently in extension the limbs in which there is a loss of motion, to avoid continued contractions, which produce alternately a shortening of the flexors, although not paralyzed.

Pemberton and the greater part of the English physicians advise, during the administration of medicines, the application of a splint to the internal face of the forearm and hand, in such a manner as to counterbalance the preponderance of the flexors. The splint is fixed by aid of bandages, and the arm is supported by a sling.

The object of this is, to establish by this means an equilibrium between the antagonist muscles, and to put the extensors in a favorable condition to act, at the time when the treatment begins to produce amelioration. It is advised, if the paralysis affects both arms at once, to change the splint from one arm to the other each day until the end of the cure. This method has been tried by Tanquerel upon five patients; but it has not been observed that this apparatus fulfilled the end intended by the English authors.

On the contrary, Tanquerel has remarked, that the immobility of the limb produced a numbness and swelling of the parts, which retarded the cure.

Tanquerel prefers to this method exercise or motion communicated to the diseased muscles, so as to bring back successively the extension.

To review what has been advanced concerning the treatment of lead paralysis, it may be said, that electricity, sulphur baths, and the different preparations of *nux vomica*, are the only remedies from which conscientious observers have obtained true

success in this disease ; and that the treatment, followed with the most advantage, is sometimes the employment of electro-puncture, together with sulphur baths, and sometimes strychnine ; in this last case, it is necessary to commence at once by submitting the patient to the use of strychnine administered internally, then by friction, and at length, terminate by the use of sulphur baths, which should be employed daily during the use of strychnine internally.

Diet and Regimen.

In all cases of lead paralysis, the diet of the patient should be considered, as one of the most powerful means upon which the physicians may rely for cure. But the first condition of success is the cessation of all work in lead, and removal from the workshops where the metal is used.

The summer season, a warm climate, a dry air, these are extremely salutary to paralytics ; it is for this reason that they should dwell as much as possible in dry and elevated places, southern countries, apartments exposed to the south, sheltered from cold and moisture. The patients should wear woollen garments to protect them from atmospheric changes, and to promote a gentle action of the skin.

The most nourishing and easily digested food, such as white, black, or red meats of animals and old birds, together with fresh vegetables, abundant in fecula, in mucilage, and in sweet matter ; these agree best with the patient.

Add to these the moderate use of wine, beer, coffee, to perfect digestion, and facilitate nutrition. All exercise of the paralyzed parts, and of the body generally, either spontaneous or communicated, is of great advantage.

It is important in this disease to keep the bowels open by the use of light laxatives.

All these means have also the end in view, of opposing relapses and causing the disappearance of the phenomena of the primitive signs of the presence of lead in the system.

CHAPTER IX.

LEAD ANÆSTHESY.

It has been already said, in mentioning paralysis, that it may influence only the principle of sensibility of the organs of the life of relation, without affecting voluntary motion.

This kind of paralysis, called *lead anæsthesy*, may be limited to the skin, or extend to the subjacent parts, or it may affect the organs of sense, as the eye, which loses the faculty of transmitting the impressions received from exterior objects.

Each of these varieties of paralysis of feeling will now be successively reviewed.

In the historical article, the small number of observations upon superficial or profound anæsthesy, which have been reported by authors, was remarked upon. Some have merely pointed out, not described, lead amaurosis. All that has been said of the causes of paralysis of motion, applies also to anæsthesy.

Without entering into any discussion concerning this, it may be said, that in twenty-three cases of lead anæsthesy, nine were endowed with strong, six with weak, and eight with middling constitutions. All, with one exception, were men; ten were from thirty to forty years of age, six from forty to fifty, two from fifty to seventy, three from twenty to thirty, and two from fifteen to twenty. Nine of these were affected with anæsthesy in summer, six in spring, four in autumn, and four in winter. Nine of these were workers in white lead, three in red lead, six were house painters, two lapidaries; one was a German card maker, one a shot maker, and one a founder.

The time that each one of these men worked in lead preparations, before contracting anæsthesy, has varied according to the trade. Thus, the white and red lead workers have labored a much less time than the house painters, and still less than the card maker, the shot maker, and the founder.

Anæsthesy appears less frequently than paralysis, for there have been observed only twenty-three cases of the first, and one hundred and two of the last. In twenty-three cases of lead

anæsthesy, 1. the disease occupied four times the deep-seated parts; 2. seven times the loss of sensibility was limited to the skin; 3. twelve times the eye was the seat of the affection; it had lost the faculty of perceiving the visual rays. In eleven cases of superficial and profound anæsthesy, three times there was paralysis of the muscles corresponding to anæsthesy, four times the loss of mobility and sensibility occupied different points, four times the loss of sensibility existed alone.

Tanquerel has met with only one patient, in whom amaurosis and anæsthesy of the skin of a limb coincided.

ANÆSTHESY OF THE LIMBS AND TRUNK.

A. Profound Anæsthesy. — It is this which occupies nearly the whole thickness of the part where it has its seat. Thus, if a limb is found attacked with this malady, the skin, the cellular tissue, and the muscles no longer feel the excitation from without.

It is very difficult to be assured if the parts beneath the skin have lost their sensibility.

But if some very fine bodies, like needles or pins, should be buried in the tissues, they determine pain there only where there is still a preservation of feeling. Electro-puncture, pressure, pullings, in short, the forced position of the limbs in constrained postures, determine pain in the normal state in the muscles, which pain is different from that determined in the skin, by aid of the same means.

If, then, it happens that the patient has no feeling of these manœuvres, exercised immediately upon the parts situated under the skin, it may be believed that the muscles have lost their sensibility.

The vessels, the cartilages, and the bones, apparently insensible in the normal state, cannot be proved by the negation of physiological phenomena, to be affected with this disease.

Anæsthesy of the limbs and trunk, considered in general without reference to the cause, has not been studied with so much care as paralysis.

Authors also when they speak of the loss of sensibility, in whatever disease, limit themselves to the mention of it, without entering into any details concerning the pinched skin, excited in every way, giving no sign of feeling, without mentioning the

state of the sensibility of the parts subjacent, and the means of proving it. It is this obscurity which renders it necessary to enter into some details relative to the seat of lead anæsthesy. In two cases of this variety of anæsthesy produced by lead, the motion of the parts already insensible was unimpaired. The patients complained only of a numbness in the parts deprived of feeling.

In one of them, the loss of sensibility occupied a part of the deltoidean region; the second patient was found affected with paralysis of motion in the thigh, and with anæsthesy of the leg.

The other two individuals attacked with profound anæsthesy, had lost the movement of the muscles corresponding to the insensible points.

In one of these patients, the loss of mobility occupied the whole extent of the superior limb; insensibility commenced in the fingers, and terminated at the union of the middle third with the superior third part of the arm. In another patient, there was paralysis of the intercostal muscles, and of the vocal apparatus, at the same time with anæsthesy of the neck and thoracic coats, even to the xyphoid cartilage.

From this point to the hypogastrium, the sensibility of the skin and subjacent tissues was exalted, and accompanied with spasmodic contractions.

B. Superficial or Cutaneous Anæsthesy.—The skin only is found to have lost its sensibility.

This may be proved, by using the means advised above, to discover the loss of sensibility in the sub-cutaneous parts; these manœuvres soon prove that the muscles respond easily to exterior impressions.

The muscles situated beneath the skin, have sometimes preserved and sometimes lost their movements.

Twice, Tanquerel has observed anæsthesy in the skin of the abdomen, the motion of its muscles continued, and in one patient there was violent colic. In one fourth of the cases of superficial anæsthesy, there was paralysis of motion of the brachial triceps, and the loss of cutaneous sensibility of the back of the middle and little fingers, as well as of the corresponding parts of the carpus and metacarpus; this anæsthesy terminated in the internal half of the middle finger, beyond which, feeling remained normal.

In one fifth of the patients, (curious fact!) there existed a

paralysis of the motion of the extension of the wrist and fingers, with preservation of feeling in the back of the hand and fingers; whilst the movement of flexion of the wrist and fingers was preserved, and the palm of the hand completely deprived of sensibility.

One case has been known, where superficial anæsthesy progressed with a profound arthralgy.

This double lead disease occupied the neck, and anterior face of the arm.

In one seventh of the patients, cutaneous anæsthesy was accompanied with hyperæsthesy of the parts subjacent, and with paralysis of motion of the corresponding muscles.

These three lead affections had their seat in the inferior limbs.

Description of the Anæsthesy of the Limbs and Trunk.

Usually this anæsthesy comes on suddenly without being announced by symptoms.

Sometimes, however, a slight numbness precedes it. Sometimes, it comes on in the midst of lead colic; often it appears a while after the arrival of paralysis of motion; or it may be preceded by arthralgy, its direct opposite.

Lead anæsthesy, like paralysis of motion, is always partial, that is, limited to a greater or less extent of the trunk and limbs.

Anæsthesy sometimes invades points of the abdomen, neck, and breast, sometimes the limbs.

Six times in ten, anæsthesy took its seat simultaneously upon the left and right of the median line.

This disease is incomplete, or complete.

One of its pathognomonic characters, especially when it is limited to the skin, is, that it passes to its highest degree very promptly in the space of a few hours, or a day; it is very movable, changing from one place and extent to another, every moment; its duration is rarely more than from eight to fifteen hours.

It is continued, yet disappears suddenly, only soon to reappear.

Profound anæsthesy is less movable than that limited to the skin.

When profound anæsthesy progresses towards a cure, the skin and sub-cutaneous tissues appear to recover at the same time their sensibility.

Sometimes, however, the skin is still more deprived of the faculty of feeling, when the muscles are already conscious of the excitations directed upon them.

When paralysis and anæsthesy exist at the same time, they may occupy the same, or different parts of the same limb. In some cases, even, these two diseases invade two opposite regions; for example, one the palm, the other the back of the superior limbs. Anæsthesy generally disappears before lead paralysis.

In the case of complication of lead arthralgy, anæsthesy may be only superficial; and the increase of sensibility has its seat in the sub-cutaneous parts; or else, these two affections occupy different points of the body.

In short, there may be seen united in the same region, anæsthesy of the skin, abolition of the motion of the muscles, and hyperæsthesy of the muscular masses. Anæsthesy of the limbs, and trunk, happening, commonly, only after the patient has been a very long time in contact with lead preparations, the signs of the primitive action of lead upon the system are usually observed, such as the yellow color of the skin, of the whites of the eyes, and the urine, emaciation, the brown color of the teeth, and the slate-blue of the gums. In all observations of anæsthesy, this coincidence of phenomena of general and primitive infection, produced by lead, has been noticed by Tanquerel.

In lead anæsthesy, there is not observed on the part of the nervous cerebro spinal centre, any immediate morbid phenomena appreciable by feeling, at least, there is no concomitance of lead encephalopathy; there is no longer febrile reaction.

Superficial and profound anæsthesy, like paralysis, is subject to recidivations and relapses.

The diagnosis of this affection rarely presents any uncertainty.

Anæsthesy, appearing in a workman who handled lead, with other lead diseases, limited to a small extent of the skin, or of the subjacent parts of the limbs and trunk, without material lesion, of the nerves and nervous centre, offers no resemblance to the loss of symptomatic sensibility by some material lesion of the apparatus of innervation; afterwards, its progress, its prompt disappearance, &c., all concur to relieve doubts of the diagnostic.

Anatomical Characters. — Tanquerel has twice made autopsies of individuals who died of lead anæsthesy; he has seen no alteration of the nervous system capable of accounting for the phenomena which had signalized this malady.

Seat and Nature. — The labors of modern physiologists upon the functions of the spinal marrow, ought to give some light, in the absence of pathological anatomy, upon the seat of the morbid condition, which determines here and there a diminution, or an abolition of sensibility. Then, to give the opinion of all who have been occupied with experiments, to prove the properties of the spinal marrow, this nervous centre incloses in itself, in distinct points, the power of sensibility and mobility; the part which presides over feeling ought to be supposed attacked by the poison in the case of lead anæsthesy.

But since the intimate nature of this nervous centre, which some observers have supposed altered, is unknown, and its action in its operation eludes our knowledge, with greater reason is it impossible to understand the immediate alteration that lead exercises upon the nervous system of the sensibility, when it produces anæsthesy.

In vain do we desire to raise the veil which conceals this work of heterogeneous combination, to penetrate its mysteries; we can only judge from its effects.

Treatment. — Lead anæsthesy disappears sometimes from the efforts of nature alone; in other cases, the insensible parts need to experience an excitation capable of giving them the faculty of being impressed by exterior bodies.

To arrive at this result, several medicaments must be employed.

Sulphur baths suffice to cure anæsthesy in certain cases, for the sulphuret of potassium employed in the baths is an excitant to the skin, as well as the subjacent parts. If this treatment is not pursued, there may be employed frictions, epispastics of different kinds, urtications even, sweats, cutaneous revellants, vesicatories, cauteries, moxa applied on the periphery of the body or the length of the vertebral column. If the disease resists all these trials, recourse should be had to electro-puncture and strychine.

During the administration of these medicines, it is best to produce revulsive action upon the intestinal canal, by means of drastic purgatives, even though there is neither lead colic or constipation to combat.

ANÆSTHESY OF THE ORGANS OF THE SENSES.

Lead Amaurosis.

The paralysis of the retina, that is to say, of the special sensibility of the eye, which is caused by the action of lead, has not been studied with more care than the other varieties of lead paralysis.

But, nevertheless, the German ophthalmists, having established and described at length a great number of amauroses of different species, founded on causes not less varied than numerous, should not pass lightly over that produced by lead preparations. This cause, without doubt, has offered them less interest than others, which they have made the base of their divisions.

On the other hand, the authors who have written upon lead colic, have mentioned lead amaurosis, without entering into any detail upon the subject, limiting themselves the greater part of the time to announcing the fact, without describing it. Perhaps, also, these last have not described this kind of anæsthesy of the retina, because this accident has passed unperceived by them, in the midst of other encephalic symptoms also produced by lead.

They have, in general, noticed the existence of amaurosis only when it existed alone, or when it had preceded the arrival of lead encephalopathy. The facts of lead amaurosis are rare, and are found scattered here and there in authors and periodicals.

Tanquerel has witnessed twelve cases of this form of lead disease. In ten, amaurosis supervened lead encephalopathy. In two cases it was unaccompanied by cerebral accidents.

Lead amaurosis may be the only symptomatic expression of poisoning by lead; in other cases, which is most common, it appears before, at the same time, or after the development of the other lead diseases, or even a greater or less length of time after their entire cure. All observations of lead amaurosis, by Tanquerel, prove this general proposition. Colic, and especially encephalopathy, are the lead diseases with which amaurosis is most often associated. But the frequency and violence of these affections, when they are first declared, seem to have no influence over the paralysis of the retina.

In uniting Tanquerel's twelve with the seven cases of other

authors, in all nineteen, it has been observed, that in five cases amaurosis preceded, and in fourteen, followed other forms of lead affection.

In these last cases, colic, arthralgy, and encephalopathy were violent, six, and moderate, or light, eight times. In eight cases, colic, and the cerebral lead disease appeared for the first time.

In six cases there had been several attacks of these maladies before; in five there had been no other lead disease, primitive, or consecutive.

Description. — Usually, fourteen times in nineteen, lead amaurosis appeared suddenly, without being announced by any special phenomena.

In four cases it was preceded by frontal cephalalgia. Finally, in another case, it came on slowly; the invasion of this affection being indicated only by an increasing weakness of sight.

In a few hours lead anæsthesy of the retina acquires its highest intensity; in a very short space of time the patient can no longer distinguish day from night. Tanquerel has once seen this affection require eight days for its complete development.

No example of amaurosis of one eye only is known. It may be complete or incomplete.

In the first case, that of complete blindness, if the eye be examined, there is observed a considerable dilatation of the pupil, and an absolute immobility of the iris, which cannot be overcome by any excitation of light directed upon the organ of sight.

The base of the eye is black; the membranes and humors transparent. Tanquerel has never been able to verify the particular state pointed out by Weller, which he gives as the character of amaurosis succeeding poisoning by lead preparations, a turgescence of the veins of the conjunctiva and scleroticæ, with a feeling of fullness in the eye; (Weller, t. ii. p. 26.) This pretended pathognomonic character of lead amaurosis, is not indicated by other facts above related. Duplay and Grisolle have sought in vain for this symptom.

When the disease is incomplete, which is the most rare case, the patients distinguish light from darkness; they seem to see all objects through a thick cloud. With some, all the objects they behold appear white. The pupil partly dilated, still preserves its mobility; in one word, the iris is still a little contracted. Very often, the eyes are affected with amaurosis in different degrees. Thus in one of these organs, the pupil is so

enlarged, that no traces of the iris can be seen; whilst the pupil of the other appears only one third, or one half more dilated, than in the normal state. Cases have been known, where the pupil was unequally dilated in its circumference, so that it had not its circular form.

For the rest, the irregular form of the ocular "*opercule*" varies every moment.

In the case of double amaurosis, the eyes, being unequally affected, it is common to observe a slight strabismus. In two cases of complete amaurosis, the pupil was found fixed and immovable. Once this opening was found unequally dilated; the iris contracted slightly at the approach of a candle, but the patient did not appear to perceive the light.

Tanquerel has never seen the motions of the eye lost, in this disease. The look is indifferent, the eyes often remain fixed, without being directed towards any object. Tanquerel has not observed with lead amaurosis, paralysis of the movements of the face, or anæsthesy of the skin of this region, or of the ocular, olfactory, or bucco-pharyngeal mucous membranes.

If amaurosis is not accompanied with lead encephalopathy, then the alarmed patient, being conscious of his situation, laments and weeps; for the rest, he experiences no suffering either in the eye or head.

The progress of lead amaurosis is in general as rapid as its invasion. It lasts some hours or days, then disappears suddenly.

In some rare cases, it disappears slowly, during a month; once it has been known to last whole years. The average term of the duration seems to be from four to six days.

When anæsthesy of the retina is declared in the midst of lead colic, this often disappears suddenly, or progressively, while the amaurosis continues its progress as if alone. Violent colics have been suddenly calmed at the appearance of amaurosis.

What has been said of colic, relative to the simultaneous progress of this disease and amaurosis, applies also to lead arthralgy.

As to anæsthesy, and paralysis of the trunk and limbs produced by lead, these two affections almost constantly survive amaurosis.

Amaurosis is developed indistinctly, during the course of all the varieties of lead encephalopathy, which it supervenes in a

very mild form; ceasing completely in one or two days, and even one month; this last case is very rare.

There are some cases where amaurosis, having reached suddenly its highest intensity, seems to disappear all at once; but the patient is only incompletely cured; the cure then progresses slowly, and it is a long time before it is complete.

When the return of sight begins to succeed amaurosis, or when it is partial at its onset, the iris offers some unequal expansions, variable from one day to another. The patient sees objects as if divided in two parts; one only of which he can see; or he can sometimes only distinguish the centre, and sometimes the circumference; the *coup d'œil* is much prolonged about the object, from fear, that not embracing it in all its extent, it should escape him; hence it arises, that at a certain distance, the same object is imperfectly distinguished.

When he looks upon a book, he sees only the letters which begin or finish a word, and not those between. When amaurosis is declared alone, isolated from all cerebral accidents, twice in twelve times it was developed slowly, and took longer to disappear completely.

Tanquerel has once seen a patient, hardly cured of lead amaurosis, attacked again, without being exposed to the contact of lead.

Another of the patients of Tanquerel, not for several years in contact with lead, was however again attacked with amaurosis, with paralysis of the superior limbs, with lead colic, and encephalopathy.

This lead disease is equally subject to recidivations. Tanquerel has never seen lead amaurosis incurable. One single case is recorded, proving that this disease may last a whole life; but the fact is not authenticated; for in this case, from the beginning, the treatment usually employed in the case of common amaurosis had been pursued; and the measures, which succeed so well usually in removing this specific lead affection were omitted, (*Lancette Française*, t. i. p. 331, May 12, 1829.)

But this interpretation must not be admitted as a demonstrated fact; for, very rarely, it is true, more easily curable lead diseases, such as colic and arthralgy remain months, even years, uninfluenced by any treatment.

Paralysis of the retina offers more chances of a prompt and speedy cure, if the attack is sudden, and the progress rapid.

When, on the contrary, the disease is developed slowly, it is proved, that sight takes a much longer time to re-establish itself.

Tanquerel has not observed incomplete amaurosis cured more quickly than complete.

That which accompanies cerebral accidents, yields, in general, the easiest.

The diagnosis of lead amaurosis may present some difficulties, which will not be extenuated to render the task more easy.

If an individual, who labors in lead preparations, is attacked with one more lead diseases, and especially with encephalopathy; if, at the same time, before, during, or after the arrival of these affections, he suddenly loses sight, then it may be believed that amaurosis has been produced under the influence of the primary effects of lead. This belief is fortified by the ulterior progress of the disease, which disappears suddenly one, two, or five days from its attack.

Other considerations strengthen this opinion of the diagnosis; for example, the patient, before coming in contact with lead, had never been attacked with amaurosis, neither he or his relations.

The amaurotic, as soon as the return of consciousness takes place, is in despair at having suddenly lost his sight, and without any thing antecedent, causing him to fear this accident, laments, weeps, &c.

All these facts will sufficiently show, that this is a case of amaurosis succeeding poisoning by lead preparations. But if it happens that one or several of these circumstances fail, then, in the absence of important information, the physician may be somewhat embarrassed. Let it be supposed, for example, that in a lead worker an amaurosis is declared before any other lead disease, and that it may not be followed by any, it would be necessary to establish the diagnosis, to take into view the trade of the patient, the instantaneousness of the invasion, and the happy and rapid termination of the disease, by aid of the treatment habitually used in lead colic, and here employed, perhaps empirically, as an efficacious remedy in all other lead affections. The practitioner would have used this treatment, with the intention of discovering the nature of the amaurosis, relying upon this old adage, *morborem naturam ostendit curatio*.

To complete this diagnosis, and to be sure that the amaurosis

is produced by lead, it is sufficient to learn that the patient has not been submitted to other causes capable of producing blindness, and that preceding his trade of lead worker, he has not been accidentally deprived of sight.

In short, it may be, that in a man employed in handling lead, an amaurosis is developed slowly, and that it lasts one, or several months without being perfectly cured, although treated with purgatives, vomiting, &c., in a word, in all those methods which are the basis of the famous treatment at the "Charity."

Here, the trade alone may serve as an antecedent, to qualify the kind of amaurosis.

But the individuals who labor in lead preparations, are submitted to all other exterior influences which may occasion a loss of sight.

Consequently, here is common amaurosis.

To decide, it would be necessary, by the physiognomy alone of amaurosis, to be able to say whether it is of the nature of lead affection.

Thus, then, the question is to be determined whether the anæsthesy of the retina, produced by lead, has a symptomatic expression as special as the cause which has produced it.

Tanquerel has never seen lead amaurosis with entire preservation of the movements of the iris, without dilatation, or constriction of the pupil.

This fact has been observed in certain other amauroses. In the case of lead amaurosis, the pupil is found nearly always dilated in all its circumference, and this singular dilatation varies with an astonishing rapidity.

The form of the ocular "*opercule*" is subject to less instantaneous aspects in other other forms of amaurosis.

Some relapses are observed, as soon as the cure is obtained, in lead amaurotic blindness, which never occur in that called *common*.

In the case of paralysis of the retina, produced by lead, the base of the eye is black, and there is a perfect transparency of the middle, which the luminous rays must traverse to reach the retina, whilst often in amaurosis not produced by poison, the color of the bottom of the eye is greenish, grayish, yellowish, nebulous, reddish, brilliant, whitish, &c.; these changes appear to be the result of an alteration of the retina: (Marjolin, Langenbeck, Kieser, Beer, &c.)

There has not been observed any tensile pain in the ocular globe, augmented by movement and exposure to the luminous rays in lead amaurosis; these circumstances, on the contrary, are frequently met with in that which depends upon some other cause.

Internal and chronic ophthalmia, iritis, glaucoma, hydrophthalmia, and cataract complicate very frequently common amaurosis; nothing of this kind has been observed in anæsthesia of the retina due to lead.

In short, lead amaurosis of a single eye has not been observed, and this disease is generally curable; the contrary often happens in that called *common*.

This rapid exposition of the comparative diagnosis of lead, and common amaurosis, proves that, in a few cases, a judgment must be formed of the nature of the paralysis of the retina, from its physiognomy only; it is possible, even, to distinguish if it is due to lead emanations, or if its origin is due to some other cause.

But to overcome all the difficulties, no point of the symptomatic expression of the malady should be neglected, however little important it may appear at first; for combined with others of greater weight, it will serve to strengthen them.

All the facts of the mysterious colic of the ancients, accompanied with trouble of the innervation and amaurosis, appear to be attributable to lead; the etiological influence of which, in these cases, has not been discovered. In effect, this blindness is now no longer observed, and the authors who have observed it, did not know that which is produced by lead emanations. In reading the observations on this colic, whose cause appears so mysterious, the absence of all etiological information may be noticed.

In the silence of authors upon this important point, since these particular modifications of the nervous system, which are produced by the influence of lead emanations, such as colic, paralysis, encephalopathy, and lead amauroses, are not observed at the present day, occurring spontaneously and independently of this cause, it must be admitted, that there cannot be established a differential diagnostic between amauroses which seem to have the same origin.

As to the amaurosis, which occurs, it is said, during the course of some vegetable colics, the absolute absence of positive

information, upon this kind of anæsthesy of the retina, renders it impossible to say, in what it may resemble, and in what differ from lead amaurosis.

Neither the published works upon this disease, or the information furnished by physicians dwelling in the countries where vegetable colic reigns, afford the elements of the symptomatic expression of amaurosis, which, it is said, occurs in consequence of these colics. Can lead amaurosis be confounded with that occasioned by emanations from vaults of privies, or even with that species of amaurosis that Beer, Scarpa, Schmucker and Richter indicate by the name of *sympathetic gastric amaurosis*?

Independently of very important diagnostic circumstances, drawn from the causes of these different amauroses, it may be repeated, that anæsthesy, due to lead, appears sometimes without colic, is often accompanied by special cerebral accidents, and, in short, that frequent and involuntary weeping, a peculiarity which is frequently observed in the two other kinds of amaurosis, does not exist in that caused by lead. From the preceding account, lead amaurosis ought to be classed distinctly in one of the divisions of amauroses. In effect the specific poisonous cause here impresses a character truly belonging to this malady.

Anatomical Characters.—In autopsy of individuals who have died from lead amaurosis, there is not found any anatomical alteration in the retina, the optic nerve, or the brain.

This proposition is based upon three autopsies, made by Tanquerel, with the greatest care, without discovery of the slightest lesion.

It is then a disease, depending upon the stupefying action of lead upon the retina, which is betrayed by a pure, simple alteration of function, without material organic lesion.

Treatment.—The principal indication, in the treatment of lead amaurosis, consists in exciting the sensibility. To obtain this result, excitants and powerful derivatives must be used; repeated blisters on the nape of the neck, behind the ears, upon the temples, and the region about the eyebrows.

Friction with antimonial ointment, setons, cauteries, moxa, are means equally used in these different regions. Some advise also to cauterize the sinciput with ammoniacal ointment.

Lead amaurosis, when it disappears quickly, during the use of all these measures, owes not to them, generally, its cure; for,

left to the efforts of nature alone, it often disappears. Such is at least the result of Tanquerel's observations.

But when anæsthesy of the retina lasts a long time, and these measures are useless, recourse must be had to more energetic means, which, acting immediately upon the eye, will contribute in a direct manner to the re-establishment of sight. Tanquerel has employed strychnine with advantage by the endermic method.

This alkaloid is given at first in doses of a sixteenth or eighteenth of a grain, and increased, according to the phenomena observed, to a grain, a grain and a half, or two grains. The application of strychnine is made by aid of two little vesicatories, placed upon the temples in front of the eyebrows, and even behind the ears.

Electricity, and galvanism, should be ranked among the means applied almost immediately upon the nervous system of the eye, to awaken there the special extinguished sensibility; electro-puncture generally succeeds best.

For this purpose, needles are implanted upon the frontal and infra-orbital nerves, at their respective exits; these needles are afterwards put in regular contact with a voltaic battery of little power.

These first trials should be renewed frequently, and in a manner continued as long as the prickings of these nerves produce no accident.

Stoll recommends, in case of amaurosis supervening lead colic, opium and camphor; "*Amaurosin in colicâ pictorum*," he says, "*opium et camphora tollit*."

Tanquerel has twice employed this means without remarkable success. He would proscribe, in general, the antiphlogistic treatment in lead amaurosis; this means, far from bringing back the sensibility of the retina, has seemed to increase the blindness, and retard the period of cure.

At the same time that these different means are employed, it is well to use drastic purgatives, such as those of the treatment used at the "Charity," oil of croton tiglium, &c. Do the good effects, that they seem to produce, result from the excitation, that they occasion sympathetically upon the nervous system of the eye?

To be sure of success, the patient must be removed from emanations which have determined lead amaurosis, and be cured of all other concomitant lead diseases.

As it happens, that the individuals who have once been attacked with lead amaurosis, are found in the most favorable condition to contract this disease again, it would be best, after the cure, that the workmen should renounce forever the occupations which have deprived them of organs the most important for the wants of life.

Lead Deafness.

Authors have spoken in a vague manner of the deafness produced by lead, without relating a single authentic observation. Tanquerel has found this accident only in consequence of lead ear-ache; but, then, deafness was only a symptom of this last malady.

END OF PART THIRD.

PART FOURTH.

LEAD ENCEPHALOPATHY.

CHAPTER I.

DEFINITION AND SYNONYMES.

WHEN lead preparations have been introduced and absorbed in the system, they may show their deleterious influence directly by encephalopathy.

The poisoning which results from it, is manifested by different morbid phenomena, such as delirium, coma, convulsions, accompanied or not with the loss of one or more of the senses.

This lead affection is found then characterized by an exaltation, or an abolition of general or special sensibility, as well as of voluntary movements, or of general mobility.

These functional lesions, may, it is true, be found in an infinity of diseases of the brain; but when they are produced by lead they have a very particular physiognomy, which may serve to characterize or define them.

Each one of these functional lesions now indicated, may alone explain lead encephalopathy.

All may appear together as an expression of this affection. It is difficult to embrace in a single definition the diversity of forms under which the morbid influence of lead in encephalopathy is revealed. It will be necessary to define separately each one of the forms of this cerebral lead disease; the description given of it hereafter will be its best definition.

It may be said, however, in a general manner, that lead encephalopathy is an apyretic neuralgia of the encephalon, with a physiognomy so changeable, that from morning to evening, from

one day to another, the symptoms which reveal its existence completely change their aspect or form.

The sudden and instantaneous appearance and disappearance of this disease should be pointed out as one of its principal characteristics.

Thus, as by the expression *mental alienation*, are designated all the forms of lunacy, such as mania, monomania, and madness, so also is understood under the collective name of *lead encephalopathy* the union of all the functional disorders which reveal the deleterious action of lead particles upon the brain, which disorders are constantly presented under one or more determined forms.

SYNONYMES.

The expressions *insanity*, *alienation*, *lead idiocy*, *madness*, *delirium*, *convulsions*, *epilepsy*, *lead coma*, have been employed until now to indicate one or more parts of the whole of the morbid lead phenomena, which will here be designated by the words *lead encephalopathy*, an expression which may be justified.

In a memoir published in the "*Journal Hebdom.*" October, 1836, Tanquerel has communicated the reasons which have led to the adoption of this term.

There is great difficulty in naturalizing pathological expressions, giving an idea of a disease not yet classed in the nosological table.

But the fear of innovation should not prevent the use of scientific words necessary to express a particular morbid state not yet sufficiently studied. To point out the lead accidents which occur in the stomach, or spinal marrow, the first authors who have written upon these diseases have been obliged to use such expressions as colic, paralysis, &c.; as it was necessary for understanding to name this particular form of lead disease.

All diseases are usually designated by some name, and not by a periphrasis indicating several symptoms. If the word encephalopathy is a little long, it is at least euphonious, and fixes in the mind the idea of the disease, without any preconceived opinion. The term lead, preceding, indicates the cause of the disease.

There will be found, then, united in this expression, the rules of a good pathological nomenclature, which demand that the

name or names of the disease should recall at once the affected organ, its nature, or its specific cause.

Since the expression lead encephalopathy has been proposed to include all the encephalic accidents produced by lead, observers of the greatest merit have used it to designate the same affection; among others, the physicians at the "Charity," Rayer, Andral, Bally; at other hospitals, Piorrey, (*Traité du Diagnostic*), Hourman, &c.

CHAPTER II.

HISTORY.

THE history of lead encephalopathy may be said to have already been given in that of colic and paralysis. All those writers who have treated of these disorders mention cerebral accidents. These authors belong to three distinct periods, the ancient, middle, and present ages.

1. In the first period, and the first who mentions delirium produced by lead, is Dioscorides, (*De Mentis Alienatione*), Aretæus, who speaks of epilepsy following colic, and Paul of Ægina, and Ætius, who refer to epilepsy and convulsions produced by lead. Later writers of this period do not recognise lead as the cause of, though they mention cerebral accidents. Avicenna describes a fatal epilepsy in lead colic. Paracelsus, (*De Morb. met.*) Fernel, Ætheus, (1550,) Charles Lepois, Riverius, (*Praxis Medica*, lib. x. cap. 1,) Drouet, (*Nouveau Conseil de la Pestilence*, 1572,) Sennertus, (*Tractatus de Scorbuto*), all these observed with surprise certain colics terminating in delirium, convulsions, or epilepsy. Imperfectly acquainted with the cause of that disease now termed lead colic, they have not pointed out lead as the cause of cerebral accidents.

2. In this period, as soon as more exact observation had shown that colic was caused by lead, it began to be supposed that it was also the cause of the cerebral affections manifested in colic. Citois, Stockhausen, 1656, Beauval, 1673, Schwaler, 1696, Boerhaave, Gokel, Huxham, Zeller, 1737, Heidenreich, (*Haller's Theses*), 1742, the article "Poitou Colic" in the *Biblio-*

thèque raisonnée de l'Europe, Wilson, in the *Edinburgh Memoirs*, Dubois, Dehaen, Tronchin, Bonté, Gardane, Stoll, Cullen, Bordeu, and Desbois of Rochefort, with Luzuriaga and Thierry, Madrid colic, all the writers in this long list speak more or less distinctly of cerebral affections in lead colic. The varied symptoms of lead encephalopathy were not wholly unknown to these authors. Sketches are here and there met with in their writings, but no detailed and satisfactory observations on the disease.

3. Coming down to the present day, a host of writers is found, who, in distinct treatises on lead diseases, or in articles published in the medical journals, have noticed cerebral lead affections with a distinctness before unknown. A chronological chart of these writers will show what advances were making in this department of medical literature. Merat considers delirium, epilepsy, and convulsions, as mere complications, not caused by lead. Larrey, who, while with the army in Spain, had great opportunity to study Madrid colic, in his observations on that, refers to a *particular malignant fever*, or "*ataxie soporeuse*," caused, as he thinks, by adulterated wines. In his memoir on this disease, a faithful but incomplete picture is given of lead encephalopathy. Jourdain, (*Jour. Gén. de Méd.* tom. 53,) Pariset, (*Dict. de Scien. Méd.*, article *Colique de Plomb*, tom. 6,) the celebrated Laënnec, and his kinsman, Meriadec Laënnec, (*Revue Médicale*, 1828,) Miguel, of the "Charity," (*Bullet. Thérapeut.* tom. vi.,) M.M. Renauldin, Thomas, De Bonteville, (*Journal Compliment. des Scien. Méd.* tt. 24 et 25,) M. Montanceix, (*Archives Médicales*, t. xviii.,) are all worthy of particular notice.

M. Anquetin (*Memoir on Lead Colic*) published under the auspices of the Society of Medicine of Paris, separates cerebral maladies from lead colic, and considers these diseases as having a common origin. Dance, in his excellent treatise upon hypertrophy of the brain, Corbin and Constant, (*Gazette Méd.*, 1830,) Duplay (*Archives Méd.*, 1834), Andral (*Clinique*), consider encephalopathy a primary effect of lead; and many articles of merit, in various medical dictionaries of this period, treat of cerebral lead affections with force and clearness; but these are only partial accounts. In 1834, Tanquerel published his thesis on lead paralysis, and in 1836, in the *Journal Hebdomadaire*, an article on lead encephalopathy, announcing also the present treatise, which he addressed to the Institute early in 1837. Since the appearance of this article, Grisolle and Nivet, in the *Journal Heb-*

domadaire and *Gazette Médicale*, have published several articles on cerebral affections produced by lead. Reviewing the labors of this long list of modern writers, Tanquerel says, that his predecessors have bequeathed to him only some observations relative to encephalopathy, and that the greater part of the recorded facts, amounting to eighty-nine, are unaccompanied by details sufficient to describe this disorder. The observations are very often incomplete, mutilated, compiled by physicians who, not always perceiving the relation of cause and effect, have supposed these lead affections were merely ordinary cerebral accidents. Rarely noticing delirium, or coma, these modern writers generally report epilepsy. There are not found in their writings descriptions of lead encephalopathy; but to define that assemblage of symptoms which characterizes this disease, preceding authors have been generally contented to indicate delirium, epilepsy, coma.

CHAPTER III.

CAUSES AND PREDISPOSITIONS.

ENCEPHALOPATHY is, of all diseases produced by lead, the most rare. Tanquerel has met with seventy cases only. No one will be tempted to deny the direct influence of lead in producing the morbid phenomena which constitute lead encephalopathy. Individuals, before being exposed to lead emanations, have never experienced the slightest functional derangement of the brain. During exposure to the action of lead, they are attacked with a cerebral malady which has a particular specific appearance, and which is often accompanied with other diseases produced by this poison. Let those same individuals be withdrawn from lead emanations, and these accidents will not return; provided the lead disappears from their systems, that is to say, the distinctive characteristics of the primary effects. In these circumstances, there must be seen a relation of cause and effect, between the poison and the lead phenomena. Science does not possess a single case, where the cerebral lead disease has been

directly produced by the application of lead to the dermoid system when the epidermis was preserved. Percival relates some cases of convulsions, occasioned by the application of lead ointments, or of Goulard's extract upon parts deprived of their epidermis. Numerous facts prove the absorption of lead particles by the digestive mucous membrane, in cases of lead encephalopathy.

Thus, cerebral accidents take place during the course of the colics of Amsterdam and Harlem, the history of which has been transmitted to us by Vantroostwyk. Several cases of colic have already been mentioned with delirium, epilepsy, and paralysis, produced by medicine containing lead, by litharge, employed to sweeten acid wines, which have been observed by Heidenreich, Gokel, Zeller, Weisman, Weffer Kœnig, Warren.

The two individuals whose history Combalusier relates, and who died from eating bread baked in an oven heated with wood of a trellis, covered with white lead, were taken with delirium and convulsions.

The experiments of Orfila have demonstrated, that acetate of lead taken in a liquid state, and remaining a sufficient time in the stomach to be absorbed, produces fatal effects dependent upon its action upon the nervous system. Is not the absorption of lead emanations upon the surface of the mucous membrane, which covers all the respiratory passages, evident in the case of encephalopathy, occurring in individuals who sleep in newly painted apartments?

Cats, and other animals who live a long time in the manufactories of white and red lead, are seized, not with paralysis only, as has been mentioned, but with dizziness, vertiginous whirling, horrible convulsions, and soporific accidents, in the midst of which they quickly succumb.

According to Trousseau, the horses employed in turning the mills for pulverizing red lead, experience semi-convulsive phenomena.

It is very difficult to imagine the possibility of cutaneous and digestive absorption in these animals; for the hairs with which they are covered, and their food, not eaten in the place of infection, should remove them from such supposition.

All those individuals who are habitually in the midst of an atmosphere filled with lead particles, or emanations, are liable to lead encephalopathy; but they cannot in the circumstances

be attacked with this disease, except by breathing the air charged with lead particles, or by swallowing a certain quantity.

The workmen who handle lead are generally attacked with cerebral lead disease, and they are so, as much more frequently, and as much more promptly, as they disseminate in the atmosphere in which they labor, a great quantity of lead emanations.

The following statistics confirm this proposition :

TABLE
OF THE TRADES OF SEVENTY-TWO INDIVIDUALS ATTACKED WITH LEAD
ENCEPHALOPATHY.

Trades.	No. of Cases.
Manufacturers of white lead,	25
“ red lead,	5
Painters of buildings,	90
Grinders of colors,	3
Manufacturers of cards and paper hangings,	3
Potters,	2
Refiners,	2
Plumbers,	3
Tin workers	1
Type founders,	2
Lapidaries,	3
Shot makers,	2
Printers,	1
Total	72

This table shows that, in general, those who contract cerebral lead disease, are individuals whose digestive and respiratory organs are found in contact with a great quantity of lead emanations.

This disease has not been found in many trades, in which the workmen do not disseminate a great quantity of lead particles in the air that they breathe and swallow, and yet, these same workmen are attacked with other lead diseases, sometimes colic. It seems from this, that a man must absorb a greater quantity of lead particles to be attacked with lead encephalopathy, than to contract the other lead diseases.

The above table proves, that lead, and all its combinations, may produce lead encephalopathy. A lead preparation occasions encephalopathy more easily, if it is easily diffused in the air in the form of emanations. Under this relation, white and red lead should take the first rank.

It has not been remarked, all other circumstances being equal, that some lead preparations, more than others, cause their deleterious influence to be felt on the brain.

The extraordinary action that determines lead towards the brain, is not felt immediately after the contact and absorption of lead emanations. One must be exposed during a certain time to their action, before their influence is manifested. This proves without doubt the necessity of the absorption of lead.

The time that each individual, affected with encephalopathy, has been exposed to the action of lead before contracting this disease, varies. Some experience cerebral accidents after a few days, and others, not till after twenty or fifty years of labor. The following table indicates the time that seventy-two workmen, affected with cerebral lead diseases have labored in the preparations of the metal:

Number of days of Labor.	Number of Patients.
8 days,	1
12 "	1
16 "	1
18 "	2
19 "	1
20 to 30 days,	4
Total	10

Number of months of Labor.	Number of Patients.
1 month,	2
1 " 8 days,	2
1 " 15 "	2
2 "	7
3 "	6
4 "	3
5 "	5
6 "	4
7 to 8 months,	1
9 "	2
Total	34

Number of years of Labor.	Number of Patients.
1 year,	2
2 years,	5
3 "	3
5 "	2
6 "	3
	15

		Brought forward	15
8 years,	.	.	1
9 "	.	.	2
10 "	.	.	4
12 "	.	.	1
15 "	.	.	1
20 "	.	.	3
52 "	.	.	1
		Total	28
		General Total	72

This table proves, among other things, that the greater number of patients have been exposed only a short time to lead preparations.

In the smallest number, the absorbed lead agent, like a germ, needs a long period of incubation to produce the formidable band of accidents of encephalopathy. Is it not so in many diseases?

The first symptoms of hydrophobia do not show themselves often in adults, until forty days after the bite; the vaccine virus does not begin to act till after three days.

The habit of frequent exposure to lead preparations does not prevent their action, but probably lessens their effects.

Encephalopathy may be developed primitively, that is, alone, and before any other lead diseases.

This result of Tanquerel's observations, is strengthened by the facts collected by Andral, Anquetin, Canuet, Dance, Harlan, Laënnec, Miquel, Renauldin, Thomas, &c.

But often the cerebral disease appears in an individual in contact with lead preparations, only after one or many attacks of colic and arthralgy. In short, commonly colic, arthralgy, and sometimes paralysis, exist at the same time as encephalopathy. There need be no astonishment at the very frequent co-existence of encephalopathy and other lead diseases, when it is known that the first of these diseases requires the absorption of a much greater quantity of poison to be produced.

Among seventy-two patients, six have been attacked with encephalopathy, no other lead disease having preceded at any time. The treatment of lead colic appears no longer to have any direct, powerful action upon the manifestation of lead encephalopathy.

The treatment only, which has no influence or a doubtful one, upon the progress of the disease of the abdomen, permits the

poison to take the right of possession in the system; it follows, that this predisposes to the development of encephalopathy, for the poison may, at any moment, be carried to the brain so long as it remains in the system. All these facts prove undoubtedly, that encephalopathy is one of the distinct forms of lead poisoning, independent of colic, and other lead diseases. The extent of arthralgy, and the violence of paralysis have as little influence as colic upon the development of encephalopathy.

There results, then, from the analysis of all the circumstances, in which the individuals attacked with encephalopathy are placed, that in subjects submitted to the same determining causes, some are attacked with this disease, while others escape.

Whence arises this difference? Is it from organism, or is there a greater or less predisposition in each individual to the influence of lead?

The characters of this disposition, so marked and evident in some subjects, must be discovered.

PREDISPOSITIONS.

It must be remembered, that in the greater part of diseases, the predisposing causes are determined with difficulty; they escape notice, or are suspected when it is too late to oppose to their action the efficacy of prophylactic measures.

They belong here, as elsewhere, to sex, age, temperament, and habits.

It is under these different relations that they will be successively examined, by the observation of facts only.

Sex. — Women, by the nature of their occupations, being very rarely attacked with the most common lead disease, lead colic, are, with greater reason, seldom attacked with encephalopathy.

In seventy cases observed by Tanquerel, three were females.

Age. — Seventy-two cases of this disease occurred in the following manner :

Below 20 years,	4
From 20 to 30 years,	20
“ 30 “ 40 “	30
“ 40 “ 50 “	12
“ 50 “ 60 “	5
“ 60 “ 70 “	1
<hr/>	
Total	79

It appears, then, from these facts, that the period from twenty to thirty, and especially from thirty to forty, most predisposes individuals to be attacked with cerebral lead accidents; but it must be remarked, also, that at this age men are found most frequently working in lead preparations.

Constitution. — It may be thought at first, that this poisonin would manifest itself most frequently in individuals of delicate constitution and nervous and irritable temperament.

But this opinion is not confirmed by facts. Among seventy-two patients attacked with lead encephalopathy, whose constitution has been noticed, thirty-six were of robust constitution, and sanguine or bilious temperament; eighteen were of weak constitution, and nervous or lymphatic temperament; eighteen were of middling constitution, and temperament little decided.

Regimen. — Does a bad diet, an irregular regimen, and a neglect of personal neatness predispose one to contract this cerebral disease?

Fifteen patients were injured by alcoholic drinks; two were very licentious; three had experienced great privations; twenty-three neglected all care of their persons. Among twenty-nine others, no relation could be discovered between irregularity of regimen and the development of the disease.

Seasons. — Temperature seems to exercise no manifest influence upon the development of encephalopathy; for, among seventy-two patients, a nearly equal number were found at each season.

Recidivations and Relapses. — Encephalopathy is subject to recidivations, when the patient is exposed again to lead emanations.

It must not be supposed that a convalescent has recovered his health from the moment that the nervous accidents cease, but the germ or lead cause of this disease is only concealed, and cannot be seized upon, though it still remains, and after having slumbered for a few days may be developed spontaneously.

Does not the same thing take place in lead colic, and in intermittent fevers caused by marshy exhalations?

Among all the subjects with relapses of lead encephalopathy, there were among them some indications of the presence of lead in the system, that is, the characters of the primary effects.

It should be remembered that workmen, during many years, handle lead with impunity; but let them be once affected with

encephalopathy, then, after their cure, they will be much more liable to contract this disease than before being attacked with it, if they return at once to their labors.

The diseases of the nervous system not due to lead, with which workers in lead preparations have been previously affected, do not seem to predispose them to contract lead encephalopathy. The causes which dispose to lead encephalic affections are little known. However, notwithstanding the obscurity that the multiplicity of circumstances still throws upon the etiology of encephalopathy, there is a fact which cannot be doubted, that is, the existence of a relation, constant, but unknown, between the production of this disease and the actual dispositions of the organism in individuals subject to the influence of lead preparations.

To explain the pernicious action of lead upon the brain, it must be admitted, that lead particles, absorbed by whatever way, in a state of vapor, dust, or liquid, are soon taken by the absorbent vessels and carried into the course of the circulation.

The morbid matter, once mixed with the blood, is carried to the organs, and may attack their principle of life. As to the intellectual, sensorial, and locomotive lesions, which constitute, by their diversity, the forms of this malady, it cannot be decided in the present state of science, what is, in each of these cases, the difference of the mode of action of the poison upon the brain, or the organic dispositions which favor the development of such or such a form of this disease.

This diversity of opposite effects of lead upon the brain is not astonishing, since it is known that the same poison, or the same treatment, often produce different effects upon two individuals, and what is more, upon the same person at different times.

Thus opium and alcohol produce phenomena entirely opposite in a number of circumstances; coma, delirium, convulsions, affections of vision, &c.

Very truly, in those cases of poisoning with so varied a physiognomy, the lead cause should act differently; perhaps even its action is manifested in distinct cerebral portions.

CHAPTER IV.

PRECURSORS.

THE cerebral lead disease may overtake the workman in a sudden and unforeseen manner, in the midst of his occupation, or be announced by some functional trouble in the brain.

In other cases indeed, different derangements have taken place in points more or less distant from the organ. Various morbid phenomena of the nervous cerebro-spinal system have been observed, which indicate, as more or less near, the arrival of this formidable malady. Thus in some cases there is remarked a violent cephalalgia, either general or partial, and often limited to the forehead.

These pains in the head, varying in their nature and intensity, are usually accompanied by vertigo, or temulency.

Sometimes there is wakefulness, or sleep agitated and interrupted by dreams and fanciful imaginings; these unfortunate persons awake suddenly full of fear, leap from their beds, and escape.

Some slight derangements have been noticed in sight and hearing; for example, dimness of sight, tingling of the ears, amaurosis, strabismus, the dilatation or contraction of the pupils; in short, a look unaccustomed, astonished, dull, or pensive, has often been remarked as a phenomenon precursive of an attack of lead encephalopathy.

One patient complained of a feeling of fullness, or heaviness, with great pain in the orbits.

In some patients, moral sensibility is increased or diminished; many seem to have a presentiment of an attack of encephalopathy, by a sadness and an extraordinary and causeless uneasiness; they become silent and indifferent to all the objects which surround them. Others become morose, and weep without cause; some have their minds agitated and change their place without ceasing, trying to divert their thoughts, and remove themselves from the sudden and great terrors which beset them. In short, a stupor, an indefinable uneasiness, from embarrassment and slowness of ideas and motions, may precede the arrival of this

disease. All these precursors take place one day, or a few hours before the invasion of the symptoms, delirious, convulsive, or comatose.

Reviewing all his observations, Tanquerel found, in ninety-two cases, twenty-six, or one in three and a half nearly, with morbid phenomena on the part of the nervous centres, which announced the commencement of encephalopathy. There results also, from the examination of these cases, that a manner of looking unusual, astonished, dull, or pensive, suddenly taking place, is the most common phenomenon which announces the arrival of this malady. By this sign alone, observed suddenly, in the course of lead colic, or in a workman in the midst of his labors, Tanquerel has sometimes been able to judge of the dangerous form of the lead poisoning, although there did not yet exist any functional trouble in the organs of the head.

Many times some functional lesions have been declared in the superior part of the digestive tube before the immediate arrival of encephalopathy; for example, of dysphagy, or a feeling of constriction in the pharynx.

Other lead diseases are often the forerunners of encephalopathy; thus, in certain cases it may be announced by phenomena which indicate a lesion of the spinal marrow, and its continuations. It is not rare to see lead paralysis precede the cerebral lead disease, (once in four times.)

In these circumstances it seems that poison ascends from the extremities of the limbs to the head.

Arthralgy often precedes lead encephalopathy, and this again is often preceded for some days by colic. The development of encephalopathy is to be feared when the patient, tormented by violent colics, is suddenly relieved of these pains, and when the precursive signs on the part of the brain, mentioned above, begin to appear. Sometimes the cerebral poisoning is developed at the moment when a fit of internal pain returns, more acute than all those which had preceded it. This case, however, is very rare.

The individuals attacked with lead encephalopathy, having absorbed a great quantity of lead particles, should manifest in the highest degree the characters of its primary effects, and this is precisely what happens.

In a small number of cases, nothing announces the future development of encephalopathy.

It commences suddenly, without cerebral precursors, and

without being preceded by other lead diseases. The cerebral lead affection oftener commences in the night, than the day; this, however, is common to a large number of diseases.

CHAPTER V.

SYMPTOMS.

THE functional expression of lead encephalopathy varies much. It may have, by turns, exaltation, abolition, or perversion of the functions of the brain.

Thus there is observed, sometimes, for a principal symptomatic expression, a delirium variable in its physiognomy; sometimes, the cerebral disease is varied by sudden disorderly movements or convulsions; sometimes, there is a heaviness, a general weakening of all the intellectual, sensorial and locomotive faculties; in short, coma, which may become most profound carus.

One of these cerebral accidents may show itself alone, during the whole course of the disease.

In other cases, they succeed each other, group themselves in many ways, and by their varied transitions, or combinations, represent the whole of the different functional derangements which constitute lead encephalopathy. It is then impossible to embrace in the same description all the functional disorders which reveal the deleterious action that lead exercises upon the encephalon.

All these considerations establish the following divisions, founded not arbitrarily, but after a complete study of the varied and constant degrees of the disease.

1. Delirious form. 2. Comatose form. 3. Convulsive form.
4. Delirious, comatose, and convulsive forms united.

This manner of describing encephalopathy, analagous to that of authors who have written upon mental alienation, will give the reader a facility in recalling without effort any point in the exhibition of the symptoms of this disease, in all its varieties. The reason for this diversity in the forms of encephalopathy, is not yet discovered.

The intensity of the affection, or the organization of the patients, the diversity of lead preparations, &c., have thrown no light upon the subject.

SECTION FIRST.

DELIRIOUS FORM.

Encephalopathy frequently shows itself under this form. In seventy-two cases, it has been found eighteen times. Delirium in these cases is the governing phenomenon of the disease.

Lead delirium is the form of encephalopathy which most often shows some precursors, on the part of the brain. There are observed, in this form, a great number of degrees and aspects peculiar to delirium. It may be light or profound, partial or general, continued or remittent, and even intermittent, accompanied or not by the loss of one of the senses.

All these characters are met with in two well marked gradations, under which the first form of lead encephalopathy shows itself — the *tranquil delirium* and the *furious delirium*.

First Variety. — Tranquil Delirium.

In tranquil lead delirium, what strikes the physician at first, is the aspect of the physiognomy, which is no longer in relation with the circumstances, in the midst of which the disease is found.

There are then observed the most fanciful and diverse expressions of face. Sometimes, the patient presents something astonished, at the same time that the features are immovable, and the eyes fixed; at other times, he seems absorbed in profound thought, with a composed face.

Tanquerel has seen three individuals, whose eyes turned upwards, with mouth open, and every feature immovable, and who seemed to have fallen into a trance.

Some have a sardonic smile, or laugh without ceasing, and without cause.

Others, on the contrary, weep frequently, and have an air of sadness and melancholy impressed on the whole person. In many, the face is gentle and benevolent, or hard and discon-

tented. Some affected with this delirium have an air of stupor; features weighed down, and eyes fixed or haggard.

If the patients are questioned about the thoughts which they have in connection with so varied a physiognomy, they will answer at random; it will be seen that their words, and consequently their thoughts, are entire strangers to the expression of their countenances.

For the rest, this state of the countenance varies with a prodigious rapidity, so that a single individual offers, in the space of a few hours, all those morbid shades of expression just analyzed.

When the patient is addressed, he may reply at first like a sane man; in such a way that one is often in doubt, whether there is really a cerebral disease.

But pursue the conversation, passing rapidly from one idea to another, then he suddenly becomes wandering, puts together words and phrases without meaning; then he returns, especially if aided by the physician, to a succession of rational ideas; by and by, the delirium returns again, and the same consequences follow.

Sometimes, the patient wanders every few moments; again, not for hours, or a day even; and in the interval of the delirium is perfectly rational.

It occurred to Tanquerel, contrary to the opinion of the learned and practised observers, to establish the diagnosis of lead encephalopathy on this changeable physiognomy, and this delirium, manifested by a singular connection of reasonable and wandering ideas. This diagnostic was confirmed by a collection of other observations.

Some patients, when questioned, do not reply immediately; they seek for expressions, and speak one word for another; or their reply may be correct; but they do not always look towards the questioner: this offers something for reflection. Sometimes, they do not appear to understand what is said to them; it is then necessary to speak very loud, to excite them greatly, to fix their attention, and sometimes they reply by one or several words, always the same, to the most varied questions. Left to themselves, the patients very often speak alone; call their neighbors, or absent individuals; some reply to all the persons that speak, or that they think they hear speak around them. The subject of the delirium varies much, and has no predomi-

nant character; but it is often observed, that the same idea returns with several fits of talking; then the subject of the wandering thoughts changes.

Speech is very often free, and the voice clear; some patients murmur between their teeth unintelligible words, or else the voice is so much weakened that their words cannot be understood. At the end of a certain time there is silence, and again talking recommences.

Alternately gay or sad, loquacious or silent, the patients are in general, during some time, affected with the same character of delirium.

They throw about their arms, uncover themselves, wish to go away, not knowing the place where they are, leave their bed to lie in another's, throw themselves against the furniture which they meet, and know but imperfectly the persons around them. But by the care of their keepers, they return to bed without resistance.

Some are affected with a light trembling, which chiefly affects the arms and face; they find a difficulty in using their limbs, and sometimes an embarrassment in pronunciation, and they stutter.

Hallucinations of sight and hearing have been observed. Many patients think they see frightful objects, which cause them to leap from their beds; one patient heard delightful music, which charmed away his weariness. Another patient said, that a woman came every morning to provoke him, placing herself sometimes before, and sometimes behind him; he heard her say the most insulting things, and one day he impatiently seized the poles which supported his curtains, thinking to catch this woman. All this was related in a calm tone of assurance and belief.

Second Variety. — Furious Delirium.

The eyes wide open, are threatening, furious, or haggard; the features contracted; a general exaltation is remarked in every act of the patients.

They cry, vociferate, swear, threaten, storm, tear their garments, break the bonds which hold them in bed, run into other rooms, attack without cause the people they meet in their passage, try to beat, tear, and bite them, and address to them the

grossest invectives. If they are not restrained, they continue to perform the most violent acts with serious consequences; some precipitate themselves from the windows, or throw themselves with such violence against the furniture, as to destroy life. If a firm resistance is opposed to the manifestation of their extravagances, for example, by putting on the strait waistcoat, their fury is redoubled, they stamp their feet, agitate their limbs, suddenly rise in a convulsive and tetanic manner, stiffen themselves, and display a strength which can be overcome only by three or four men.

Once chained, they grind their teeth, spit at the assistants, call for shears and knives, pull at their bonds, and exhaust themselves in vain efforts. Some individuals there were, upon whom, for a precaution, or to prevent them from leaving their bed, the strait jacket was used. This constraint agitated and enraged them; unbound, they became calm. Sometimes the pain produced by vesicatories determines the same effects. In many patients this delirium is accompanied by a spasmodic contraction of the muscles of the face, rolling of the eyes, pressure and grinding of the jaws, movements of the tendons, or tremblings of the limbs.

Terrors, visions and other analogous phenomena, which constitute these hallucinations, besiege the minds of these persons. Some, according to Legrand, cry, weep, lament like children, because they see at their ears pistols to kill them; they supplicate and implore help to remove these causes of their despair. Others, according to Launay, abuse the nurse who has been sent, as they suppose, to poison them.

They then touch with their finger the medicine, and repulse it with great violence. Another patient, an ancient military man, saw a regiment of cavalry ready to attack him. In short, some, in consequence of fatal hallucinations, fancy they destroy life by throwing themselves from a more or less elevated place, thinking they pass through the door of their chamber or workshop. These patients, in general, talk much, their discourse consists in an incoherent association of ideas and words, their speech reprimanding, abrupt, stuttering, consequently often unintelligible. This condition is attended by convulsive agitation of the muscles of the larynx; the sound of the voice also acquires more energy. The talking and the fury return in a simultaneous fit; sometimes, however, the patients speak with a certain

energy, without the rest of the locomotive apparatus participating in the intellectual disorder. Moments of repose or calm succeed this general exaltation of the nervous system, but at greater or less intervals. Some days and entire nights, twenty-four, twelve, six, one hour, or some minutes are spent in this furious state, then a calm takes place, but lasts a short time only; the furious state soon returns.

In other cases, very rare, there are observed some almost imperceptible moments of remission; the patient is almost constantly agitated during the course of the disease.

Notwithstanding this violent attack, displayed in all the actions of the nervous system, from time to time some very rational answers to the questions addressed, may be obtained from the patients; but, that they may be so, one must quickly fix their attention upon some very simple questions, which require but few words and little thought. Without these precautions, they begin a phrase, and after having pronounced a few words distinctly, they stammer out the rest; at other times, their words no longer represent their thoughts; they try in vain to express them, and this enrages them.

The patient, after having replied in one or two rational words to the interlocutor, pursues his wandering thoughts. The reason is a little better during the calm which succeeds the furious fit.

In one case, the patient frequently carried his hand to his head and complained of pain there, when questioned upon the subject. The face, usually of an earthy yellow, is sometimes slightly injected, but it has not that warm coloring which is generally remarked in inflammations of the encephalon; that as well as the body, is covered with perspiration in consequence of many fits of fury. There are some phenomena on the part of the tongue and teeth, which at first sight might be thought to indicate typhoid fever. In consequence of long and violent fits of delirium, when the patient has spoken with vehemence, the inside of the mouth is dry, the dry tongue becomes furred, sometimes chapped and trembling. Some pseudo-membranes yellowish, and sometimes blackish, cover equally the teeth and gums.

If, in these circumstances, the pulse is accelerated and irregular, in a word, if it offers the characters of the nervous pulse, and the body be covered with sweats, then it would be easy to mistake this state for a grave fever of bad character. The sen-

sibility of the skin is preserved; only as the patient does not discern the different sensations that he experiences, it is necessary to pinch him a little energetically, so that he may perceive this painful sensation. When we meet lead paralyses which supervene during the course of this delirium, or which happen at its termination, the movements of the limbs and especially of the arms are often badly performed, accompanied with tremblings and irregular and disordered movements, nearly analogous to those observed in chorea.

The step of the patient is tottering and uncertain, and if attacked with amaurosis, he walks pitching from side to side.

Tranquil and furious delirium rapidly reach their highest state of intensity. It may happen, however, that for some hours, and even whole days, the disease may remain incomplete. It consists, then, only in an illusion of the external senses, and an incoherence of ideas, which produces a singular confusion of the names of persons and places. These instances of aberration with which is often associated a trembling of the limbs, and an abrupt, hurried manner of speaking, are separated by lucid intervals, during which the patient rectifies the erroneous judgments that he has made.

Soon the duration of these intervals diminishes, and then the delirium is general. As soon as the delirium is completely developed, it proceeds with an incredible irregularity; it exalts, increases, diminishes its intensity from one moment to another, without any order. In other cases the delirium proceeds by access; remission is marked by a certain lucidness of ideas, which sometimes causes one to think that the disease of the brain has disappeared; but, deceitful hope! suddenly an attack of violent delirium returns, and carries the patient to the tomb.

The two kinds of delirium just described usually succeed each other irregularly through the whole course of the disease, and from one moment to another. But each of them may show itself alone; however, it is more common to meet the tranquil delirium only than the furious; the latter shows itself very rarely isolated. Several individuals have been known to be affected with tranquil delirium in the day, and to be taken with the furious at night.

Let one now represent to himself these two kinds of delirium in their different gradations, and let him suppose that from time to time the patients are affected with drowsiness, as if asleep,

and he will have an idea of the *ensemble* of the delirium produced by lead. But this drowsy state must not be confounded with lead coma, to be discussed hereafter.

The following are the usual characters of this somnolence, which does not declare itself usually until one or many days after the complete development of the delirium. The eyes are closed, or half closed, and sometimes unequally open, but the eyelids are hardly closed for a second, or a minute, when they open only to close again. But there may be heard during all this time a snoring, analogous to that of a true sleep; sometimes the patients turn themselves on different sides in their beds, or mutter some words without meaning. This somnolent state does not last long; usually after a few minutes, or an hour, the kind of delirium which preceded this state returns; then the dullness returns after a period of talking and agitation; so that the physiognomy of this disease is represented by this alternate delirium and drowsiness. The periods of somnolency are not so long as fits of delirium. In some rare cases there is an interval of many hours between the furious fits; then, during all this time the patient is somnolent, and appears sleepy. This long duration of somnolence is a happy augury in the progress of the disease. The tranquil, as well as the furious delirium, is interrupted by drowsiness. This semblance of sleep is felt during every hour of the day, but rarely in the night.

When, in consequence of a fit of furious delirium, there is somnolency, upon waking, the patient may again have a furious fit; but the most common case is that where the tranquil delirium supervenes for some instants at least; then the countenance has an expression of marked dullness, the look is astonished, and the patients appear insensible to every word addressed to them. When delirium approaches, a long and profound sleep that may not be confounded with the somnolent state takes place, in consequence of which, a complete change is observed, often an unexpected amelioration.

In certain cases, it is true, this gratifying state lasts only a short time; and in some hours or days, without any known cause, the same nervous troubles return.

To sum the whole up, the most complete and regular progress of the delirious form is this: the cerebral disease commences with tranquil delirium; at the end of a certain time some furious fits are declared. Later, somnolence arrives, then only the tran-

quill delirium shows itself at longer or shorter intervals. At length true sleep follows this somnolency, on awaking from which, the patient returns almost completely to his reason. From this time he strongly desires sleep, it is irresistible. Fatigued, and the limbs feeling as if broken, there is still in his expression a little of a surprised air.

SECTION SECOND.

COMATOSE FORM.

Lead encephalopathy was manifested in six of Tanquerel's patients, only by coma more or less profound, that is, by a collection of symptoms entirely opposed to delirium. In one of these forms there is observed truly a sinking or depression, in the other, on the contrary, commonly a super-excitation of the nervous system.

In a certain number of cases a slight delirium, (*sub-delirium*), interrupts the lead coma; but then this last accident is most general and most marked; delirium, on the contrary, is only a passing and consecutive accompaniment.

It is then necessary to study these different states, which constitute two varieties of the second form of the cerebral lead disease. In one, coma exists alone; in the other, it appears with *sub-delirium* during the course of the disease.

First Variety. — Coma.

Individuals, who are in contact with lead preparations, suddenly fall into a comatose state in the midst of an appearance of good health, or, what is more rare, during the course of colic, or other lead disease; in some cases, amaurosis is distinguished as the precursive symptom. In the highest degree of this variety, the patient is immovable, the limbs gathered upon the body, the eyes closed, or half closed; at one time a snoring is heard, which seems like a profound sleep.

From time to time, he utters some heavy groans, turns in his bed, opens his eyes only to close them immediately. If spoken to, he cannot be drawn from the comatose state in which he is plunged.

But let any one agitate him, by pinching him sharply, and then he feels; sometimes the painful sensation is felt through the brain. Then, he opens his eyes, looks around, and without replying to any question, falls again into his lethargic sleep. Some automaton-like movements of the head, trunk, and limbs, are observed from time to time.

The pupils are dilated, or sometimes contracted; they remain in this state at the approach of a bright light, or else slowly contract. There is, evidently, amaurosis in the first case. Sensibility and mobility are blunted, but not abolished; the jaws are firmly clenched; there is also an abrupt diduction of the lips, accompanied with a strong expiration, a movement commonly called, "*smoking the pipe*."

Second Variety. — Sub-delirious Coma.

In this variety, the patient, after having been plunged into a sleep more or less profound, seems to awake suddenly; then, he opens his eyes, mutters nearly always the same unintelligible words, or distinctly pronounces them without any meaning; he turns and turns again in his bed, rises at last and takes the most fanciful postures, then falls back into his first sleep.

If he is briskly excited during his lethargic state, he at first raises his eyelids a little, and then closes them immediately. Finally, by continuing the use of stimulants, his eyes, which are fixed and haggard, are completely opened. If, at this moment, he is questioned with much attention, he will sometimes look fixedly at the person without speaking, or else he replies with stammering, in a very laughable and sing-song manner; to touch the patient, to cough even, determines a return of this continued repetition of the same words.

One individual always repeated the words, *pater-noster*, &c. &c., every time he was pinched, agitated, slightly touched, or even at a slight cough. Another patient at the "Charity," at every excitement, powerful or light, pronounced these words, *pater, terer, moterterer, pafenterer*, all his expressions terminating in *er*.

When the patients are awakened from their stupor, their harsh jargon often expresses discontent, and then they turn with ill humor away from the interlocutor. Sometimes, when they are awakened, they articulate the first words of a reply, and mutter the rest as they fall again into their stupor.

In some cases they can give a rational reply, provided it does not require more than one word; thus, if they are asked, "Do you suffer in your heart?" they say, yes or no; and even without pointing out the probable place of their suffering, they may be made to indicate it; to do this, they slowly carry their hand towards the painful part; they may also, if it is insisted upon, be made to put out their tongues. All the other organs of the senses are blunted, but they always transmit impressions, of which, one may be assured in producing these sensations; to make these experiments, it is necessary to act energetically. These two varieties of coma show themselves alternately, or isolated during all the course of the disease, and observe no order in their appearance or disappearance.

It is this form of encephalopathy which presents the least often any precursive signs, which, when they do exist, offer nothing special; its sudden and instantaneous development serves greatly to establish its diagnosis. Very rarely the comatose form produced by lead shows itself alone, during the course of the disease, without being preceded or followed by delirious or convulsive forms.

Usually, coma appears succeeding one or many attacks of epilepsy, and rarely in consequence of violent fits of furious delirium; in this last case there are usually observed the three primary forms of encephalopathy, during all the progress of the disease; this will be proved in another place.

SECTION THIRD.

CONVULSIVE FORM.

Convulsions are the most frequent lead cerebral accidents, but very rarely are found alone. Tanquerel has observed them alone only five times. Nearly all kinds of convulsions may take place in lead encephalopathy. Stoll has already remarked this.

The convulsive form may be irregular, that is to say, may consist of partial or general convulsions, which do not resemble any convulsive disease of the nosological table; in short, it is generally characterized by some attacks of epilepsy, epileptiform, tetaniform, or cataleptiform; in nearly all cases the principle of

motion is not alone altered, the intellect is more or less affected, before, during, or after the arrival of lead convulsions; all the observations of Tanquerel and other authors confirm this proposition; this is the reason why the convulsive is placed after the delirious and comatose forms.

First Variety. — Partial Convulsions.

The face, or one side of it only, one or several limbs are agitated by rapid convulsions, analogous to those produced by electric shocks. Instead of this effect, all these parts may be struck with permanent contraction, remaining a longer or shorter time without interruption.

There is, also, a clenching of the jaws, grinding of the teeth, and stiffness of the limbs, more or less bent or extracted. The partial convulsive movements are declared suddenly, and at very short intervals, co-existent with delirium and somnolency, or else coinciding only with a cephalalgia, more or less intense, and divers hallucinations.

Second Variety. — General Convulsions.

In this variety of encephalopathy, much more frequently than in all the others, the arrival of cerebral accidents may very often be attributed to the violence of colic. These general convulsions happen very often in individuals exhausted with the pain of lead colic, and who present in their features an appearance of grief, weakness and very marked discomposure. The patients are taken at first with an agitation characterized by a general trembling, with a chattering of the teeth, analogous to that of the cold stage in intermittent fevers.

Feeling the attack coming on, they try to fall as gently as possible. This state is soon replaced by spasmodic shocks, which agitate the whole body.

The sudden and unruly motions of the limbs consist rather in rapid shocks, than in complete convulsive movements, which bring them alternately into flexion and extension. Convulsions are more marked in the face and superior limbs than any where else. The jaws clashing with violence produce a loud sound; these unfortunates cannot open their mouths, or move their tongues. These shocks themselves are followed by a general

stiffness of the limbs and trunk. During all the progress of this scene, the patients have not completely lost their reason. Their appearance at this moment is staring, the open eyes are fixed and immovable; when they are questioned quickly, they look awhile at the person and hardly reply by a cry. This scene lasts one or several minutes; then the face which is pale retakes its expression, the limbs become more supple, but seem as if bruised. Voice and speech become easy, and the patient may usually converse rationally with the assistants. A drowsiness greater or less is manifested in consequence of this agitation, and reason returns after this sleep. In other cases, very rare, as soon as the fit terminates, a furious, or a tranquil delirium appears.

The distinguishing special difference in this kind of convulsions of *lead epilepsy, properly so called*, is the preservation of partial sensation during the attack.

The patients, the fit once finished, will relate in part what they have experienced, and what has most fixed their attention during the attack, for they could not attend to all which surrounded them; they were not sufficiently masters of their will. Some also say, that a thick cloud seems to cover their sight during the fit, and even some minutes after it has ceased. In many observations by Tanquerel, these convulsive attacks were preceded by severe pains in the limbs and violent colic. One patient was attacked with colic in consequence of a fit of convulsion of this kind. Merat and Andral have recorded in their works, three cases of general lead convulsions. These convulsions cannot be referred to hysteria, epilepsy, or still less to catalepsy. They must then be described in a particular section.

When general convulsions are observed in a patient, they need not always be referred to hysteria or epilepsy, for may not the general exaltation of the nervous system, which presides over mobility, be shown under a great number of varied forms, following the organic and other conditions which favor its development?

Third Variety.—Epilepsy.

Epilepsy is the most common form, by which the brain manifests the deleterious action exercised upon it by lead. Tanquerel has observed thirty-six cases of lead epilepsy. Lead epilepsy is

sometimes declared suddenly, without being announced by any precursive phenomena; sometimes derangements are observed in the head, before the attack. If there is seen, suddenly, and without cause, a distracted and preoccupied air, in an individual who labors in lead preparations, or who is affected with lead colic, let one hold himself in readiness, for a violent action of the locomotive apparatus will take place.

Sometimes, these individuals, in their physiognomy, words, and gestures, affect an indifference which strikes the observer, astonished as he is, at the decided change in the character, supervening without apparent cause. Some patients are affected with dizziness, which makes them think that all objects around them are constantly turning. Among others there exists, some hours or days before the attack, a little agitation or a slight frontal pain. In others, epilepsy is preceded by amaurosis. Never, hitherto, could the existence of *aura epileptica* be proved. One patient only, uttered a cry at the commencement of the attack, another was heard to groan. Finally, the patients may be under the delirious or comatose form when they are taken with epilepsy. Epilepsy presents differences according to the degrees and aspect of the attack.

Thus, some patients experience only a light attack, characterized in the following manner: Individuals suddenly fall, deprived of reason, general sensibility is abolished, the eyes are fixed, and the head immovable; they do not speak, perhaps sometimes utter groans; only slight convulsive movements are observed.

This state usually lasts several hours. When the patients resume their reason, they do not immediately enjoy their intellectual faculties in their full power; they cannot recall their attack, or the circumstances which preceded it; their physiognomy bears the impress of profound stupor; their limbs are trembling; they totter when they walk, but seize hold of exterior objects with hesitation; their ideas are confused, their speech slow and embarrassed.

Science records only two facts of this kind. This light attack may precede the highest degree of the epileptic fit, which will be hereafter described.

The most violent attack of lead epilepsy, is characterized in the following manner: Immediate loss of reason, the globe of the eye turned up, the head immovable, the face suddenly injected,

and in an instant nearly indivisible, the florid red color changed to the paleness of death. If the individual walks, he falls back like an inert mass, insensible to all exterior excitants. Some convulsive movements pass through the limbs, especially the superiors; the body is stiffened, and some unruly movements take place, during which the patient is forced out of the bed where he reposes. Soon this preliminary state acquires a prodigious increase. The hand is closed, and the thumb placed convulsively within. Some violent spasmodic shocks agitate the whole body. In the limbs, they consist of precipitate and alternate movements of flexion and extension, which last until the end of the attack, or are replaced by a tetanic tension, or stiffness. In this last case, the head is much thrown back, the muscles of the trunk are so much contracted, that the patient may be raised as if he were a solid body, like a bar of iron.

Flexion of the limbs is impossible; grinding of the teeth alternates with clenching of the jaws.

When the stiffness predominates on one side, the face is horribly disfigured, the commissures are much drawn to the right or left, and the eyelids unequally opened. This state of general rigidity may terminate the fit, or be followed by a rapid succession of sudden contraction, alternating with a complete relaxation of the muscles. Respiration itself is modified by the convulsive state of the muscles of the breast; it becomes short, painful, interrupted, jerking, noisy, and afterwards stertorous. Then a foamy saliva, often bloody, is thrown out with noise and difficulty; this last fact is explained by the reversed position of the head of the subject, and by the rapidity with which the air enters and leaves the breast; the tongue, usually bitten, (twenty-four times in forty-six,) accounts for the mixture of blood with the saliva. During the progress of this horrible scene, the face becomes almost purple, or else it preserves its paleness, the lips bluish and discolored; the eyelids are often half open, and the globe of the eye convulsively upturned. The eyelids are often wide open, then the eyes are fixed, haggard or rolling, and even agitated with convulsive movements; in some cases, these membranous veils are completely closed. The pupils are usually immovable, dilated, or contracted. The circulation participates more or less in this general disturbance.

The pulse acquires frequency and force, or preserves its habitual regularity and slowness. This last case is the most

rare. There is usually a decided swelling of the veins of the neck.

Urine, and the fecal matters may be, and commonly are, excreted with force, and by jerks. After a time, which varies between two and thirty minutes, the convulsive movements cease. The limbs fall into complete resolution; the skin is covered with sweat; respiration is re-established, becomes slow, profound, sighing, and, sometimes, sonorous during the expiration. In some cases, respiration was suddenly interrupted, and there was heard, almost immediately, a sucking noise, as if the glottis was convulsively closed, and it was only after an effort, which appeared very great, that the air contained in the lungs, was driven out from the breast with a sonorous noise; the relaxed lips were frequently puffed out, and the cheeks were swelled at each expiration. Paleness replaced the purple hue of the face, the mouth remained open, the eyes were half closed, and the pupils widely dilated. Then, a derangement is remarked in the circulation, which has not been observed during the attack; the heart beats quick and irregularly, the pulse is so depressed and frequent, that it cannot be counted. Some convulsive movements, slight and partial, may still disturb different parts of the body. There is found here, oftener than in the two other forms of encephalopathy, the movement of the lips, called "*smoking the pipe*." Some individuals utter profound sighs, cries, or howlings, at the termination of the crisis.

Finally, sensibility returns progressively. In consequence of this attack, reason is never complete. The patient may fall into a more or less profound drowsiness, or be taken with new fits of epilepsy, between which there is no interval. These three cases will be now examined; by reason of the peculiar physiognomy, that each one of them impresses upon the *ensemble* of the disease, they claim particular attention.

Epilepsy, coma. — Most commonly, coma, which amounts to the most profound carus, succeeds immediately one or many attacks of epilepsy. The patient is immovable in his bed, eyes closed, or half closed, and mouth open. His reason is completely annihilated, no vestige of it can be discovered. Sensibility and mobility, although diminished, are preserved; sometimes there are dull mutterings; from time to time, the opening of the eyes, or else, some automaton-like movements of the trunk and limbs, are the only acts which take place externally.

A noisy breathing, which takes place at certain intervals, creates a complete illusion, and makes one think the patient in a calm and profound sleep. Sometimes, the inspirations are rare, and deep. This coma lasts for some hours, perhaps days; in other cases, it is interrupted by new attacks of epilepsy, more or less frequent, followed by coma; and thus it goes on to the end of the disease.

Tanquerel has seen, in the space of twenty-four hours, thirty-four fits of epilepsy interrupt the comatose state.

It should be remarked, that coma which succeeds epilepsy becomes, in general, more marked in proportion as the convulsive attacks are frequently repeated. After the first attack of epilepsy, the patient may be half somnolent, the eyes are half or wholly closed; in this last case, they very often open; then the look is wandering, and the expression dull; hearing weakened; he seems to understand but half the questions addressed to him; he often replies in monosyllables, or not at all.

Epilepsy, delirium. — As soon as the attack of epilepsy terminates, the patient is delirious; he is affected with one or both varieties of delirium before described.

At the end of a certain time, this state may be interrupted by new fits of epilepsy, which are also followed by delirium. The following state often supervenes, in consequence of epilepsy :

The look is fixed, the countenance dull, eyes wide open and projecting. The patient answers no questions, but talks to himself. Some individuals, in consequence of epilepsy, have been known to show only a kind of astonishment accompanied with wakefulness, and a slight incoherence of ideas, which the physician recognises only by examining the patient with much attention.

In other cases, in consequence of an attack of epilepsy, the patient is overwhelmed and stupefied, his limbs are weak and trembling, speech is embarrassed and rapid, ideas confused.

If the attacks of epilepsy are renewed, delirium is declared by degrees, and even with violence.

Fourth Variety. — Convulsions or Epileptiform Movements.

This name is given to lead convulsions which have some connection with epilepsy, but which are also different. The epileptiform movements are constituted by a loss of feeling, and by

convulsions in the limbs and trunk. These fits are so near together, that there is scarcely any interval between the convulsive movements; they are nearly continuous. General spasmodic shocks constitute this disease, with alternate flexion and extension of the limbs. The convulsive contractions are otherwise less energetic, than in the great attacks of epilepsy. Usually there is no foam at the mouth, or stertor, and the face does not become swollen and florid from arterial injection, or "*vultueuse*."

Such is the convulsive state, designated by the expression, *epileptiform convulsions*. It may last from one to twenty-four hours. If the epileptiform movements are not continued, and if they supervene during the short interval, which separates them from coma or delirium, where they show themselves in consequence of a decided attack of epilepsy, they then very often indicate the happy termination of the malady.

Fifth Variety. — Catalepsy or Cataleptiform Convulsions.

Authors do not mention this kind of convulsion produced by lead. Tanquerel has observed it but twice. The patients, lying calmly in their beds with their eyes closed, represent an individual sleeping peacefully. When the skin in any point is pinched, pulled, or burned, the patient gives no sign of feeling. It is nearly impossible to awaken him and fix his attention.

If one suspends, without support, his fingers, hands, forearms, arms, legs, and thighs, in any position, constrained or easy, they remain fixed in this situation for some seconds or minutes, then shake a little, and at last fall upon the bed; if the trunk is stiff the patient cannot be seated, a bar of iron could be as easily bent; when the trunk is supple, then the cataleptic, placed in a sitting posture, remains there some hours like a statue, then falls. When this state has lasted a quarter, or half an hour, or many hours, the scene changes completely; the patient, with closed eyes, begins to execute many very expressive movements with his limbs, head, face, and body. These movements agree together, and seem to refer to the expression of one idea.

But every moment the expression of this mimic state changes. Sometimes he is silent, sometimes utters cries and makes fruitless efforts to speak; his language is only an unintelligible stammering. Pinched at this moment, he expresses, by a sudden

movement, that he feels acutely. The superior limbs can no longer be placed in a fixed position; they stiffen themselves against the motion communicated. When these movements and cries have lasted some minutes, the most complete calm takes place; the patient falls back into a cataleptic state, then the mimic movements return, to which cataleptic coma succeeds, and so on. There are still some signs of intelligence. One patient expressed by significant signs that he wished to drink; then suddenly threw with force upon those around him the ptisan which he had in his mouth. Then the cataleptic state shows itself again; there is complete insensibility, and preservation of the position given to the limbs. In short, after some hours or entire days of the duration of these alternations of lethargy and agitation, the patient suddenly opens his eyes, feels physical wants, asks to eat, drink, &c. Let him be then excited, he converses easily.

Left to himself he often talks alone, expresses with great volubility an infinity of incoherent ideas; in the midst of this disorder of the thoughts, if his attention be fixed, he sometimes replies very justly in one or two words, then he continues his wanderings.

The same idea is the subject of the delirious thoughts for some minutes, then it changes; sometimes the patient is taken with great agitation, he tries to rise, apostrophizes, invokes, endeavors to beat and bite those who approach him; in a word, furious delirium is manifested.

The following day delirium is gradually dissipated, or presents the exacerbations and remissions of which mention has been made.

SECTION FOURTH.

REUNION OF DELIRIOUS, COMATOSE, AND CONVULSIVE FORMS.

This form of encephalopathy in which delirium, coma, and convulsions appear, presents a high interest, for it is the type of this disease, and also the most frequent form. The three forms of encephalopathy described before may be replaced, united in different manners, and form varied combinations.

If lead encephalopathy should assume, during its course, the three forms just described, they may be often seen succeeding each other without any order. Delirium, coma, and convulsions, may indistinctly commence, terminate, or show themselves in the midst of the course of the disease.

Thus encephalopathy, once declared, during all its duration, delirium, coma, and convulsions appear suddenly any moment, without any regularity in their progress. To-day, at one moment delirium exists; the next, it is coma, which is replaced by convulsions; another day these forms will appear in an inverse manner. All the forms of cerebral lead disease appear and disappear suddenly, without order, and show themselves independent of each other.

It is this, which, in the course of a single case of encephalopathy, makes one observe the different imaginable transitions of delirium to epilepsy and coma; but this case is more rare. Each patient generally passes only once or twice through those primary forms of encephalopathy.

The usual and most regular case is the following: the patient is at first taken with delirium, sometimes so light that the physician does not recognise it: at the end of some hours, or one or two days, an attack of epilepsy supervenes, in consequence of which, the patient becomes drowsy for some minutes; then he seems to awake, to talk all day; delirium, tranquil or furious, is then more decided than before the fit of convulsions; the same day, the night following, or the next day, one or more attacks of epilepsy supervene again. After each fit, the drowsiness is more profound and long; it is interrupted only for an instant by a half waking of some minutes, during which the patient murmurs some words, then sleeps again.

If the epileptic fit is renewed often, coma becomes very profound, then death takes place. In the contrary case, the patient seems to wake suddenly from his drowsiness after some hours or a day. One is astonished to find him quite, or nearly quite reasonable, but he has an irresistible inclination to sleep.

The fourth day he feels roused, and converses well. For some days he appears like a man recently awakened. In some cases of this form of lead encephalopathy, delirium is predominant; in others, it is coma; it is frequently seen where epilepsy is the culminant symptom. In general it is remarked that delirium becomes more decided, coma more profound, and epilepsy more

violent, in proportion to the duration of the disease, and the frequent repetition of these disorders.

SECTION FIFTH.

SYMPTOMS COMMON TO THE DIFFERENT FORMS OF LEAD ENCEPHALOPATHY.

Lead Complications.—Other lead diseases may complicate encephalopathy. Lead colic, as has been before stated, frequently accompanies the cerebral disease; it often, also, exists before cerebral diseases, but is developed at the same time with them. Some cases have been observed, in which the disease of the abdomen has disappeared, on the access of the affection of the head, or is manifested after the occurrence of this last.

During the course of encephalopathy, a certain number of patients have a consciousness of abdominal pains; it is in the delirious forms chiefly that they complain of colic pains, especially if earnestly desired to say in what part they suffer. Sometimes, if the abdomen is compressed, the forehead may be seen wrinkled, and indicating a painful sensation, even though the patients do not complain, or else, in an automaton-like manner, they carry their hand to the abdomen, at the same time that the features of the face are drawn up; they often change their position, and utter at the same time lamentable cries. It might be affirmed, that there still exist some traces of consciousness, capable of making the patient feel the effects of abdominal poisoning. It has been noticed, that sometimes, in coma, the patient may give the physician some proofs of the sufferings he has still the power of feeling. Often, the patients, having no longer the faculty of discerning what passes within them, may not be able to tell if abdominal pains exist. This non-revelation of colic may, perhaps, be due to the following cause: when the brain and abdomen have been simultaneously affected, the encephalic symptoms may take an intensity, such as may efface those of colic, so that the digestive functions appear perfectly healthy.

But in these two circumstances, the form, the hardness, the contraction or suppleness of the abdomen, joined to constipation, retention of urine, or to the easy stools and the examination of fecal matters, as well as the symptoms antecedent to the arrival

of encephalopathy, may yet afford some proofs relative to the existence of colic. Some patients, after being cured of encephalopathy, continue to suffer with colic.

Lead paralysis, once in fourteen times, immediately preceded the attack of encephalopathy.

Once in seven times, the loss of mobility appeared during the course of the cerebral disease, in the following manner. Encephalopathy had already passed over the greater part of its usual duration, when, upon occasion of a super-excitation or diminution of its symptoms, a slight trembling of the limbs suddenly took place, followed by weakness and paralysis. Once in seventeen times, paralysis appeared as the termination of an encephalic disease. In this case, the cerebral affection ceased completely when the loss of mobility was declared. Once in thirty-six times, paralysis and encephalopathy appeared simultaneously. The most common case is that, in which paralysis is not observed immediately before or after the access of encephalopathy, or during its course. Sometimes, encephalopathy, when it succeeds paralysis, causes this last to disappear; it is the crisis. Lead arthralgy may precede, accompany, or follow the cerebral disease. This form of lead poisoning follows the same progress as colic.

Lead amaurosis appears very often in company with lead encephalopathy. Lead anæsthesy may precede, arrive at the same time, or terminate an attack of encephalopathy. This complication shows itself more frequently in the comatose form than in others. When, in the delirious form, the patient still preserves a certain consciousness of existence, he is much terrified at the loss of sight. In the case where amaurosis occurs suddenly at the commencement of the cerebral affection, it follows usually all the phases of this last, increases and decreases with it.

Sometimes the pupil is contracted in the delirious form; this peculiarity is not observed in the comatose form; in this last case, it is unequally dilated or contracted. The dilatation and contraction of the pupil succeed each other every moment without appreciable cause of this instantaneous change. Sometimes the eyes are affected with strabismus, they are not directed towards the interlocutor when they are open, and do not seem to distinguish any exterior object. A mucus, thick and gluey, often moistens the edge of the eyelids, and fastens them together, especially in the morning. Thus lead may produce alternately

in one and the same attack of poisoning, colic, arthralgy, paralysis, encephalopathy, in such a way, that it seems, that after the cure of each of these affections, the poison is transported, by a kind of metastasis, successively upon the organs where these diseases have their seat. Lead encephalopathy supervening usually, only after the patient has been a long time in contact with lead preparations, with this affection, there usually exist the signs of the presence of lead in the system.

Tanquerel has witnessed one case, where there was abundant vomiting of fecal matters, in an individual affected for the fourth time with encephalopathy. He had neither colic or hernia, or disease of the abdomen, which could account for this accident. In the delirious form, the drinks are swallowed with great ease, and in great abundance, sometimes at a single draught. Some patients complain of great thirst. The jaws being strongly clenched together, in individuals affected with comatose and convulsive forms, it is difficult to open their mouths to introduce drinks. Urine and the feces are unconsciously evacuated; the first often abundant, and the second rare, but a lax has been observed in some cases. At other times, the bladder and rectum are distended enormously by their retained contents. The urine, examined with much care, has been found red, yellow, or lemon color, without a trace of albumen.

Respiration is very often found much deranged, in consequence of the violent perturbation of the nervous system. It is frequently accelerated during and after many attacks of furious delirium and epilepsy. Coma retards it sometimes sensibly, especially in the movement of expiration. In some cases, respiration is noisy, profound, and even stertorous.

One patient has had frequent hemoptysis, which had never taken place before the cerebral lead disease; the spitting of blood was not, probably, accompanied with tubercles; and nothing, then or since has caused a suspicion of a lesion of the pulmonary apparatus. Another patient had spitting of blood, followed by pneumonia, after a great number of attacks.

Circulation, which is placed under the immediate action of the nervous system, would necessarily experience some alterations in this disease, so remarkable for the violent derangement which it causes in the whole system. But this function remains very often normal during the serious disorders which constitute lead encephalopathy. The pulse, from seventy to eighty-five

pulsations, is observed very full and regular in a large number of cases. Sometimes, it preserves the characters of that of colic, in case of co-existence of this last affection.

Usually circulation offers no other alteration than that produced by the extravagance of the disordered movements of the patients, or the exaltation or sinking of the nervous element. Furious or loquacious delirium quickens the current of the arterial blood, and modifies its impulsive force every moment. Convulsions usually determine a great frequency, or a sensible depression of the pulse. During coma, the pulse acquires slowness or hardness. Thus the state of the pulse presents variations in connection with the different forms of encephalopathy, whose progress it follows. Generally, the pulse is accelerated more and more in proportion as the disease advances. At the commencement of the affection, it offers a normal frequency, whilst at the middle and end it acquires very often an excessive frequency, and considerable depression. The blood drawn from the vein has presented only in a single instance the inflammatory coat, but in this patient there was no phlegmasiac complication. The blood of twenty-two other patients, examined with much attention, has presented no appreciable alteration.

The heat of the skin is not usually increased, unless in consequence of violent fits of furious delirium, or severe and long attacks of epilepsy then it is covered with sweat, more or less warm and viscous, more abundant about the head and breast, than on other parts of the body. Beside these circumstances, this membrane preserves its freshness and normal suppleness. There is not then, usually, any fever in encephalopathy, since there are not found united in a continued manner, and during the whole progress of the disease, frequency of the pulse, general heat and dryness of the skin, headache, injection of the face, and slimy furred tongue. The tongue offers nothing peculiar; often dewy and moist, it becomes dry and coated in consequence of long continued furious delirium. This dryness is communicated to the teeth and lips; these last are bordered with a circle of foamy saliva, owing to the force and frequency of the cries. The tongue is usually bitten in attacks of epilepsy; Tanquerel has observed it twenty-eight times.* Then it becomes enor-

* It was before stated *twenty-four* times in forty-six. — S. L. D.

mously swollen, which is an obstacle to pronunciation and clearness of voice. In some cases speech is abrupt, jerking, stammering; which arises from the agitated state of the muscles of the larynx. In other cases, aphony and difficulty of pronunciation result from lead paralysis of the vocal apparatus. During the delirious form, appetite is sometimes preserved, if one may judge from the eagerness with which the patient eats. One individual eat with an appearance of great voracity during the whole course of a cerebral lead disease. Nutrition experiences rapidly a sensible modification. Encephalopathy has lasted but a few days, when the face is elongated, and thinned, the trunk and limbs lose all their roundness; it might be called a general melting of the whole body.

CHAPTER VI.

PROGRESS, DURATION, AND TERMINATION.

LEAD encephalopathy is a disease essentially irregular and insidious. The symptoms acquire an extraordinary gravity, and seem to threaten the life of the patient, when suddenly this violent assemblage of phenomena gives place to a state of greater hope. But this confidence in the quick return of health is deceitful, for it is soon succeeded by violent attacks, either of epilepsy, or furious delirium, which, followed or not by coma, produce death in a few hours. It is difficult here, as in other maladies, to predict the progress of the disease, which is every instant deceptive.

There are some cases, where the progress of encephalopathy can be calculated. When the delirious form exists alone, for two or three days, then it may be hoped that no new cerebral symptoms will occur, and that the disease will soon terminate happily. Before this time the sudden arrival of coma, and particularly of convulsions, is much to be feared. If the affection begins with coma, the delirious form may be expected to supervene, in the course of the first twenty-four hours; this would be a happy augury. But, if coma lasts without inter-

ruption for two or three days, there would then be danger of immediate death, brought on by this state, or a fatal attack of epilepsy. In the most favorable case, coma is only fleeting.

The progress of the convulsive form is very difficult to foresee; if the convulsions are partial or general, it might be hoped that they would soon disappear, to return no more, or but rarely.

Lead epilepsy allows no opportunity for divining what will be its progress; for it appears and disappears with the rapidity of lightning. The epileptiform movements last a longer time than the attacks of epilepsy; but, being more continued, they offer more regularity in their progress, and a less imminent danger. As to the union of the three forms of cerebral disease, what has been said at the commencement of this article accounts for it perfectly well. The very irregular progress of this form, in which delirium, coma, and convulsions appear and disappear in a day or a moment, with the greatest irregularity and rapidity, proves, that here, the usual progress of the greater part of the acute affections of the brain does not occur. The duration of the malady varies according to the form of the accidents; the delirium may be prolonged from a few hours, to seventeen days; it usually disappears at the close of the third or fourth day. The attacks of epilepsy are repeated at intervals more or less near, from some minutes to six or seven hours.

The number of fits which succeed each other in the space of twenty-four hours, varies from one to thirty-four. The cases where only one attack has taken place in a day, are more rare. In one individual, the attacks returned for two days at the same hour; sulphate of quinine produced no change for the better in the state of the patient; these fits last for different periods of time, one or several days, not beyond a month. The comatose form lasts from one to three days. The duration of the fourth form of encephalopathy is usually longer than that of the others; it varies from four to seventeen days.

In some very rare cases the duration of the affection is short; the disease terminates fatally in a few hours, minutes, or seconds. But individuals attacked with encephalopathy generally succumb, or are cured with an equal rapidity. Sometimes the disease lasts only a few hours, and terminates by a return to health. Lead encephalopathy terminates in health, in another disease, or in death. The return to health may take place suddenly, progressively, or by successive ameliorations. When the

return to health is sudden, a calm, which announces the end of the disease, supervenes in the midst of the most violent symptoms.

In the most rare cases, where the return to health is progressive, the cerebral functions gradually approach their natural state, the countenance begins to resume its proper expression, and the movements become regular. When the cure takes place by several successive and distinct ameliorations, the patient experiences sometimes in a few hours, in consequence of phenomena which have not taken place before, for example, after a sweat, an alvine evacuation, or a bleeding at the nose, a relief which seems to indicate the commencement of convalescence; but these mitigated symptoms remain in the same state for several days, until a second amelioration takes place, and thus it goes on. The termination of each form of encephalopathy will now be examined.

In the delirious form, the patient, after several fits of talking and fury, exhausted with fatigue, falls into a profound slumber, from which he awakes after a long time without showing the least disorder in understanding. Calm, and having no idea, or only a confused recollection of what has passed, even of things he had appeared to notice, he experiences sometimes a little cephalalgia and nervous susceptibility, which renders any noise, or too much light, painful to him. In other cases the fits of fury, or talking, diminish suddenly, in a very remarkable manner, delirium, if it was furious, becomes tranquil, then reason almost insensibly returns; the patient recognises his relations, and the persons who surround him; his conversation is a mixture of reasonable and wandering ideas. The face is calm, but continues wandering; the eyes are haggard and dull, wide open, and projecting, as if they were out of their orbits; the limbs and trunk are bruised and immovable. The following days this state grows gradually better and better, sometimes there is a sensible improvement from day to day. This happy state may last for some days. Then suddenly, without apparent cause, the convalescence is retarded by a return of delirium; but these fits are generally short and soon disappear. The patient is restored to health, he eagerly demands food, complains of great weakness, and cannot support himself on his legs. His body has diminished in size.

Cessation of coma takes place progressively; amaurosis ceases by degrees; the patients at first open their eyes, then close them,

by and by they keep them open altogether. They attend to the persons who speak to them, without replying to their questions; they answer certain easy questions, though often in an incomplete manner, proving that they have at least partly understood the questions addressed to them. By degrees they recognise their friends and relations. The intellectual faculties resume their empire, but the patient has no remembrance of the past. He thinks he has awakened from a profound sleep; he is fatigued, and the first sensation he experiences is that of hunger. This state is very slowly dissipated, and has sometimes the behavior of a recovery from a chronic disease. But reason always returns as lucid and as extensive as before encephalopathy, and the face loses this stupid appearance and resumes its usual spirit.

As to the convulsive form, it is very important to distinguish the different kinds. The partial or general convulsions terminated, the intellect, if it has been affected, returns to its normal state; but intelligence never returns immediately, that is, in half an hour after a decided attack of lead epilepsy, as is the case in common epilepsy.

Tanquerel always observed, at least in twenty-four hours or a few days, a greater or less profound derangement of the intellect, owing to coma, delirium, or fresh attacks of convulsion. In these circumstances, the reason being much shaken, has more obstacles to conquer than in the two preceding forms.

The three forms of encephalopathy, when they all appear during the disease, terminate favorably by following the progress of the last form which appeared. Very frequently, in other circumstances, the termination and assemblage of symptoms are very peculiar, and seem to unite the different terminations of each form of the disease. The patients, after having passed and re-passed through the most violent perturbation of the nervous system, fall into a state resembling idiocy. Some have a dull, careless air; others gaze upward; the countenance resembles that of an automaton; not a ray of intelligence animates their wide open and stupid eyes. They remain immovable in their beds, constantly in the same position, heedless of evacuations.

They are regardless of the preservation of their lives; they must be fed like children; like machines, they do not try to perform the functions necessary to life. If left to themselves, they are silent night and day. When addressed, they reply in a tone of perfect indifference, without looking at the person. Others

have an air of the greatest unconcern in conversation, as if they would say — "*let me rest ; you are not worth the trouble of my replying to you.*"

Some speak in accents full of emotion, implore your friendship, your pity, ask pardon for crimes they think they have committed, for the trouble they have occasioned, and such like things. These unfortunate beings despair, because they imagine themselves doomed to certain death, or that their wives and children are dead. But all these ideas and thoughts are constantly changing. This lead idiocy lasts from one to twenty days. During all this time there are singular variations of better and worse in the patient. To-day, he is very much interested about his health ; to-morrow, he has fallen into a general drowsiness. It must be also noticed that at this period fits of delirium or convulsions re-appear, but do not usually increase the idiocy.

Finally, a moment arrives in which the countenance of the patient unfolds like a flower, his eyes acquire their accustomed vivacity. His conversation, clear and precise, will give all desirable information upon his present state ; of the past he has no remembrance. Mobility, sensibility, and the other sensations have resumed their sway. All the functions of the system have recovered their regular exercise, the disease has disappeared ; there now remain only general weakness and great thinness. In all this period, or during convalescence, cerebral accidents sometimes appear again with great violence, at a time when they are least expected, and draw the patients rapidly to the tomb.

Diarrhœa, epistaxis, and pulmonary hemorrhage, coincide with the happy end of the disease.

If death is considered as the termination of encephalopathy, which is the most common case in the observation of authors, then the accidents take an inverse order. Delirium becomes more and more furious, and the talking more and more constant. The traces of reason which may possibly exist disappear completely. The patient, weakened by this continued tension of the brain, expires during this state of excitation, as if the nervous system had exhausted all its action. In other cases furious delirium gives place to complete weakness. The patient is half drowsy and delirious, with a low voice : the pulse is small, respiration stertorous, pupils immovable, the extremities are cold, life is extinct.

In the case of coma, general annihilation is declared by de-

grees, a cold sweat covers the whole body, the organs of internal life no longer perform their functions, respiration is embarrassed, retarded, becomes noisy, stertorous, the head is thrown back; finally, the throat rattle appears, and death takes place. Lead epilepsy, when it is about to terminate fatally, generally recurs frequently, and with continually increasing violence, there is scarcely the slightest interval between the fits; death takes place then in consequence of asphyxy, caused by the violence and frequency of the attacks. In some cases death has taken place suddenly, as if by suspension of the nervous action, even after one attack of epilepsy in persons, who, an instant before, had manifested only a kind of astonishment, accompanied by wakefulness and slight incoherence of ideas, in such a way as to render it doubtful whether they really were diseased.

The fourth form of encephalopathy, which may have a fatal termination, usually has the following progress: After rapid alternations of delirium, convulsions, and coma, the patient has a violent attack of epilepsy, which terminates his life; or a profound coma supervenes, from which he does not recover. In some cases, furious delirium terminates the scene fatally.

In relation to the termination of encephalopathy by another disease, Tanquerel has never seen this affection degenerate into meningitis, or encephalitis; there is no observation in science, worthy of confidence, in which this complication is noticed. In two cases, colic succeeded cerebral accidents. Sometimes the arrival of lead paralysis coincides with an amelioration of encephalopathy, which it may suddenly displace.

Very often, in consequence of attacks of delirium, and convulsions, or relief from coma, the patients are affected with lead pains in the limbs. In one case, according to Dehaen and Bonté, epistaxis supervened at the close of the cerebral accidents; in this subject, there was then, for the first time, proof of the existence of pulmonary tubercles. They have also noticed, at the close of the cerebral disease, the existence of colic, which in some cases had become very severe.

In seventy-two cases of lead encephalopathy, reported by Tanquerel, death occurred sixteen times, and cure, fifty-six; whilst in the ninety-nine observations of other authors, death took place sixty-one times.

CHAPTER VII.

DIAGNOSIS.

HERE, as in other lead diseases, there is an assemblage of symptoms, whose physiognomy and progress reveal to the observer the etiological cause, and consequently, the kind of affection which it has produced. To establish the diagnosis of lead encephalopathy, it is necessary on the one hand, in reference to the cause, to examine all the antecedents of this malady; and, on the other, the group of phenomena which signalize it during all its course.

The different etiological circumstances, which have preceded the cerebral accidents, are of the highest importance in establishing the diagnosis of lead encephalopathy. If the patient has worked in lead preparations, or has been exposed to their action in any way, there would already be some symptoms, by which to suspect the nature of the cerebral disease. But, if to these are joined the proof of the existence of lead accidents, immediately anterior, and, especially, some actual abdominal symptoms, there might be a greater degree of certainty. But it must be said, that these considerations would not be sufficient of themselves to decide in a direct and positive manner upon encephalopathy.

The greater part of the encephalic diseases may be developed in workers in lead, even during the course of colic, for all is not lead disease in a lead worker. It is only by inference, that such a judgment is formed. The elements of the diagnosis should then be drawn also from the form of cerebral accidents. The precursors, symptoms, progress, duration, and different terminations of encephalopathy, have a physiognomy as different from other diseases of the brain, as the cause which produced them. In no other disease of the encephalon are there found united cerebral affections as opposite and varied, whose progress is as irregular and duration as short. It is not indeed impossible, that, in some very rare cases, there may be seen in the brain, an assemblage of symptoms not produced by lead, which yet resemble lead encephalopathy. The same thing happens in lead colic, paralysis and arthralgy. If to establish the diagnosis

of diseases, some absolute signs are necessary in all cases, and without exception, not one of the diseases of the nosological table could always be diagnosticated.

The convulsive form of lead encephalopathy should not be confounded with the agitation produced by the violence of lead colic. Some individuals who suffered horribly in the abdomen, gave themselves up to the most extravagant acts in hope of relief, being driven to extremities by the pain; but they still retained their reason, and when the pain ceased, they could give an account of what they had done during the exacerbation of the colic. Most inflammations of the cerebral nervous system begin by a period of *excitation*; all the symptoms then reveal this character. There is a decided stimulation, or exaltation, then a period of oppression. This is as a period of rest; there is possibly a return towards the period of exaltation; nothing is yet disorganized.

But if the disease makes new progress, if nothing arrests it, the period of *collapse* arrives, all symptoms of excitation subside, all irritation ceases, there is a complete depression of strength, material disorders have become permanent, and nearly always beyond the reach of art.

This gradation in the progress of the disease is seldom or never found in lead encephalopathy. Delirium, convulsions, or coma exist alone or alternately; in this last case, during all the course of the disease, they appear and disappear without order, and with the rapidity of lightning. The symptoms of drowsiness and exaltation succeed each other at short intervals, in a few hours or days, drawing the patient to the tomb, or restoring him to health in as rapid a manner. They have no fixed duration, like the phenomena which resemble inflammation of the brain, and its envelopes. Delirium of cerebritis, and meningitis, does not become by turns tranquil and furious, general and partial, and the patient does not preserve all his physical strength, and give himself up to the greatest extravagances. Somnolency consists only in a dullness of intellect, sense and mobility, and there is not so profound a coma as in lead encephalopathy.

Convulsions are not united with this alternation of coma and delirium, and with a tendency to epilepsy. The circulation and other functions of the system, in encephalopathy, are not modified as in inflammatory diseases of the head. In this disease, the slowness of the pulse is remarkable at the commencement, later,

when furious delirium, or violent and rapid convulsions are declared, the circulation participates in this state of exaltation; but this excitation is only for a moment, at least, till the patient approaches the fatal term. The paralysis which succeeds the alterations produced by inflammation of the brain, and its meninges, arrives gradually, and in the latter part of the disease; here, on the contrary, it may arrive at any moment without fixed time.

As to the chronic diseases of the intracranial organs, such as softenings, tubercles, cancer, hydatyds, fungus, &c., their slow and gradual progress mark a sufficient difference between them and lead encephalopathy.

Cerebral apoplexy somewhat resembles the comatose form of lead encephalopathy. But in this last, coma is much more profound, or, if it is light, it is followed by delirium, and interrupted, which does not commonly happen in apoplexy. When the phenomena of exaltation take place in this disease, they are the effect of an eliminating process, and consequently appear much later.

In apoplexy, paralysis is limited usually to one side of the body, there is hemiplegy; whilst in lead coma, when paralyzes exist, which is rare, they are limited to one or several muscles of one, and oftener of two sides of the body, and there is never facial hemiplegy.

Many neuroses of the brain might be confounded with encephalopathy. Mental alienation, with forms as varied as those of cerebral lead disease, has certainly many points of resemblance with this lead affection. But there are also numerous differences. Lead delirium, both the tranquil and furious, may take the forms of mania. In both diseases, there are some fits of furious delirium, followed suddenly by a calm, or agitated talking, without very furious exaltation. Somnolency occurs in lead encephalopathy, even after the most tranquil and least loquacious delirium; this phenomenon shows itself equally after attacks of furious delirium, and this accident does not appear in mania. Usually, after fits of the most ferocious mania, the patients become calm, but not somnolent. The features are as greatly altered in lead delirium as in mania; in this last, the face expresses the ideas which preoccupy the patient, and his talking confirms this fact; nothing of this kind exists in encephalopathy; countenance, ideas, talking, all are at variance.

Amaurosis very often accompanies lead delirium; it is a phenomenon that authors have not noticed in mania. The skin of the face and the rest of the body, in lead cerebral disease, presents an ash, or a wax yellow color; nothing of this kind exists in mania. The duration of these diseases will distinguish them from each other, if what precedes did not serve, except in some rare cases, to establish the diagnosis. Lead delirium usually lasts from four to five days, at the most seventeen; mania has no limits, it generally lasts months, or years, or even the whole life. As to monomania, it cannot be confounded with lead delirium, such analogous accidents are not primarily produced by lead.

Idiocy sometimes occurs in consequence of one of the three forms of lead encephalopathy. The most common case is that where it appears at the end of the fourth form. It offers characters common to that of mental alienation, which is always consecutive either to mania, or monomania. But lead idiocy has this peculiarity, its intensity varies in an extraordinary manner, from moment to moment, from day to day. To-day, the patient is careless, and indifferent to all that passes around him, immovable in his bed, face dull and without expression; to-morrow, he will reply with a certain pleasure to the questions addressed to him, will eat with satisfaction, move in his bed, and be grateful for the cares lavished upon him; but the third day, all this amelioration disappears, and the patient returns to his vegetative life. These sudden and ceaseless changes are observed in the consecutive idiotism of lead encephalopathy, which are not seen in that of mental alienation.

During lead idiocy, acute accidents may appear suddenly, as delirium, epilepsy, and coma, which last only a few moments; mania or monomania very rarely interrupt the course of the idiocy, and folly. Lead idiocy does not last beyond fifteen days or a month, that of alienation lasts some years, and often conducts the patient to the tomb. Mental alienation, accompanied by paralysis, may be more easily confounded with lead encephalopathy also complicated with paralysis. But the form of the cerebral and paralytic accidents serves to indicate them.

Does common epilepsy differ from lead epilepsy? It is usually easy to establish the different diagnoses of these two diseases, provided that their precursive and consecutive phenomena, and their progress, are taken into consideration, for if only the fit

itself was witnessed, it would often be impossible to establish a marked difference between the convulsive movements. All these circumstances will now be examined.

Aura epileptica has not yet been observed in convulsions produced by lead. In the greatest number of cases, common epilepsy proceeds slowly; it is a disease essentially chronic, which lasts several years, or a whole life. Its attacks usually return at distant intervals; eight, or fifteen days, months or years. In lead epilepsy, essentially acute, the fit is rapidly renewed, two, three, thirty times a day; in this last case, one fit is hardly finished before another begins, and so on. When the patient is once restored to health, if he is not again exposed to contact with lead, and if the characteristic phenomena of the primary effects are dissipated by appropriate means, he will never again in the course of his life be attacked with epilepsy.

In a great many epileptics, convulsions are usually more marked on one side of the body than on the other; this circumstance has not been observed in lead epilepsy. In encephalopathy, convulsions have a greater energy; there are violent, almost tetanic contractions. The tongue is very frequently bitten in lead epilepsy; this accident is rarely seen in common epilepsy. The duration of the fit is much longer in encephalopathy. It is generally, after a very long time, that epilepsy, from a moral or hereditary cause, becomes fatal; lead epilepsy terminates in death in a few hours, or days. If attention is given to the phenomena which precede or follow the two epilepsies, there are still more precise symptoms to establish a good diagnosis. Lead epilepsy is always preceded or followed by delirium, or coma, which is not always the case in common epilepsy. Somnolency, which may, sometimes, reach coma, it is true, often follows common epilepsy, but this symptom does not, in general, last as long a time, nor is it so complete as in the lead convulsive form.

In common epilepsy, drowsiness always succeeds the attack immediately, but never precedes it; at the end of half an hour or an hour the patient usually awakes, his reason completely returns, or else he has an air of remarkable imbecility, which soon disappears if the disease does not last long. In lead epilepsy, on the contrary, consecutive or primitive coma at the attack, lasts several hours, or many days. The patient is drawn from this state only to suffer renewed attacks of convulsions, or de-

lirium. The following is an important remark: It is sometimes difficult to recognise the delirium, which, in certain cases, follows the attacks of epilepsy; it might be thought, when first seeing one of those individuals who has had an attack of lead epilepsy, that he was in the full possession of his reason. But, if carefully observed for some time, and at various hours of the day, it will be perceived that he wanders at intervals of greater or less length. Reason has not yet entirely resumed its sway. An observer, not knowing this circumstance, would not perceive this *sub-delirium*, which would not then assist to establish the diagnosis; he would, on the contrary, think that the consequences of common epilepsy were the same as those of the convulsive form of lead encephalopathy. Thus, lead epilepsy never exists alone; it is always preceded or followed by a more or less profound derangement of the reason, that is, by delirium or coma; common epilepsy rarely shows itself with these cerebral accidents, there is generally complication. Sometimes, however, the attacks of common epilepsy, frequently renewed, and for a long time, terminate in mental alienation, a complex disease not observed in consequence of lead epilepsy, and which is easily distinguished from comatose or delirious forms, which precede or follow the convulsive form of encephalopathy. All these considerations prove that there is a difference between lead epilepsy and common epilepsy.

No case of hysteria, produced by the influence of lead preparations, has been discovered. How is lead catalepsy to be distinguished from common catalepsy? In this last case no delirium or coma is observed after its cessation, while delirious or comatose forms always precede or follow the cataleptic form of lead encephalopathy, in such a way, that from one day, or one moment to another, some delirious, comatose, or cataleptic forms succeed each other with the greatest irregularity.

As to tetanus and hydrophobia, these two diseases present some special, marked character, which easily distinguish them from other diseases of the nervous system; consequently they cannot be confounded with the convulsive form of lead encephalopathy. Intermittent fever, when its fits are rapidly repeated and confused, may present some analogy with the delirious and convulsive forms of encephalopathy. But the commencement of the fever fit, its ever increasing gravity, the state of the circulation and the spleen, its disappearance by the use of quinine, &c.,

are so many signs which will prevent its being confounded with the cerebral lead disease.

All the diseases which suspend for a while the cerebral functions, and produce more or less profound coma, may, in part, resemble the comatose form of lead encephalopathy. Tanquerel does not speak of nervous apoplexy, the symptoms of which, are the same as those of cerebral hemorrhage.

Cerebral commotion, which consists, it is said, in a general disturbance impressed upon the nervous encephalic mass, shows itself by a profound coma, which lasts some hours or days. Before going farther, a remark must be made, which Tanquerel thinks may, perhaps, surprise many. He states that he is not convinced of the existence of coma, produced by a shock of the brain without material lesion of the encephalon, or its envelopes.

After minute researches on this subject, he has arrived at this result: that there is not recorded in science, a single observation worthy of confidence, of coma produced by a percussion, which has lasted one or many days, the autopsy of which, made with care, has discovered the material causes of coma. But to prove that this accident is due to the pure and simple concussion of the brain, no alteration accounting for it, would have been found necessary in these cases.

However, coma, without paralysis, supervening in consequence of a fall, or a contusion, may be confounded with the lead comatose form. But some differences seem indeed to exist; in the first disease, there is immobility and complete insensibility, which does not exist in the second. In encephalopathy, the patient opens his eyes from time to time, utters cries or heavy groans, or else turns in his bed and makes different movements, which does not take place in that called *coma, from commotion*. Lead coma is suddenly interrupted by convulsions, or replaced by delirium; nothing of this kind is seen in coma.

Amaurosis frequently accompanies lead somnolency; has this phenomenon ever been noticed in the affection now compared with it?

One case, more embarrassing in the diagnosis than any other just reviewed, may present itself. For example, if a house painter falls from a staging, and comatose phenomena, without circumscribed paralysis, immediately appear in consequence of the fall, it is difficult at first to say, whether this state is the

result of a fracture, or a commotion in consequence of the fall, or if it is due to lead, whose effects have surprised the workman in the midst of his labors. To throw some light upon the question, after having examined the bones and soft parts of the head, let one inform himself very exactly, whether the workman, immediately before the accident, was affected with colic, or if some derangements on the part of the brain had not already begun to manifest themselves, or finally, if he had experienced any such disease, before the fall.

Suppose the reply is negative to all these questions, then, the physician not discovering any fracture of the skull, will believe this to be a case of cerebral commotion. But the ulterior progress of the disease will soon completely remove all these doubts, for it has already been said many times, that lead coma and the coma of commotion have a very different appearance.

Vegetable emanations, such as the air charged with the odorous principles of hyacinth, lily, orange, and narcissus, produce cephalalgia, nausea, vertigo, sometimes even syncope, but these accidents of short duration, can be mistaken for symptoms of encephalopathy only by an unpractised observer.

Asphyxy may, in general, be easily recognised by the union of symptoms under examination, with knowledge of the cause which has produced them. But suppose that the etiology of asphyxy is not known sufficiently, even after examining the patient, could this state be confounded with the comatose form of lead encephalopathy? It cannot be; the purple color of the face and body, absence or difficulty of respiration, disappearance or great feebleness of the pulse, loss of the senses, and complete immobility are the constant phenomena in asphyxy. In lead coma, very opposite symptoms take place; the face is usually of a leaden or pale yellow hue; respiration is easy, or noisy and not deep. The pulse has preserved its force and normal frequency, mobility is blunted, but not destroyed.

Certain cerebral diseases, which consist, like encephalopathy, in a poisoning whose effects are especially felt upon the nervous system, will now be compared.

Drunkenness, *delirium tremens*, narcotism, poisoning by acrid narcotic substances have analogies with lead encephalopathy. Individuals plunged in lead coma have been many times compared to men *dead drunk*. But this state, produced by alcohol, lasts twelve, and oftener twenty-four hours; the patients exhale

the smell of the liquors which have intoxicated them, they often vomit. They are not affected with amaurosis, an accident so common in lead coma.

Delirium tremens offers a great resemblance to the delirium produced by lead. The difficulty of the diagnosis is much greater in certain cases, as the greater part of lead workers, especially painters and white lead workers, are addicted to drinking. In *delirium tremens*, as in lead delirium, there is no fever.

The patients have sometimes that compound of tranquil delirium and reason, which is called reasonable folly; they are by turns, furious and wakeful. But in oinomania, the delirium turns principally upon the occupations of the patient; the face is injected, eyes brilliant, muscular contraction is always impeded, rapid movements of flexion and extension, becoming every moment more defined, agitate the limbs unceasingly; the patient frequently demands drink. All these circumstances are not met with in the delirious form of encephalopathy. Sometimes, in this disease, there is a trembling or slight agitation of the limbs, but it cannot be compared, in intensity and form, to the extravagant and often energetic movements of *delirium tremens*. In the lead affection, the fit of talking and fury alternates with somnolence, which is not observed in oinomania.

Some well informed physicians mistake lead coma for narcotism; there are indeed many points in common between these two affections.

In both cases, the patient is plunged into a profound coma, accompanied or not by snoring; feeling and mobility are blunted, but not destroyed, the pupil is dilated or contracted, from time to time, the eyes are opened only to be immediately closed, especially when the patient is excited. But in narcotism, one does not hear those complaints, or those inarticulate and stammering words, which often mark lead coma. Poisoning by opiates presents another very important phenomenon, copious sweats. The face of the individual affected with lead coma has a wax or leaden yellow hue; that of the patient affected with narcotism offers nothing peculiar.

Poisoning by acrid narcotic substances, strychnine, &c., is characterized by somnolency, agitation, convulsions, or delirium. But these three orders of phenomena show themselves alone, and rarely in consequence of each other; besides, they have not the

irregular behavior and rapid succession of exaltation and calm of lead encephalopathy.

It now only remains to compare with lead encephalopathy, the diseases of organs more or less distant from the brain, which, from sympathy, disturb the cerebral functions. It has been at all times observed, with what facility the abdominal affections react upon the nervous cerebro-spinal centre; the observation is very exact, that most of these diseases, when violent, bring on cerebral disorders.

Inflammations of the digestive tube, when extensive and acute, are accompanied with cephalalgia, delirium, or somnolency, and twitchings of the tendons.

Tanquerel has observed pneumonia complicated with nervous delirium; this delirium was sometimes calm, sometimes accompanied with great agitation, and was even furious; the patients constantly romanced. In these individuals the affection of the breast prevented the idea of lead encephalopathy; afterward speech and voice were strong and decided, the face resembled that of a maniac, and there was no interval of somnolency, as in the delirious form of lead encephalopathy.

Eruptive fevers sometimes present in their most advanced stage somnolent delirium, with partial convulsions, which have not the character of lead encephalopathy. Cholera morbus has been compared by some physicians to poisoning by lead preparations. (Dubois d'Amiens, *Traité de Pathologie*.)

Tanquerel sees no analogy between diseases so opposite. It might easily be conceived that the characters, enumerated as belonging to well defined lead encephalopathy, could undergo some variable modifications every time it is complicated with a cerebral disease, or with an affection easily reacting upon the encephalic centre; it is then that the differential diagnosis of this affection will become of extreme difficulty.

The diseases that may be most easily confounded with lead encephalopathy, are, nervous delirium, *delirium tremens*, coma, resulting from cerebral commotion, mental alienation, and common epilepsy. All these affections, separately, have been compared with each form of the cerebral lead disease; but most commonly, encephalopathy shows itself with two or three forms united, and in none of these diseases do such opposite disorders exist by turns, and with so many returns in a few days. It must then be concluded that the assemblage of symptoms,

progress, duration, and different terminations of lead encephalopathy, are sufficient, in the greatest number of cases, to diagnosticate this affection. When all the antecedent circumstances are known, such as those of trade, colic, &c., joined to the physiognomy of encephalopathy, they greatly increase the certainty of the diagnostic.

In some obscure and doubtful cases, the memory will serve better than an examination of the patient to satisfy the mind of the physician upon the kind of case he has before him.

It is of great importance to diagnosticate lead encephalopathy, though its origin is not known. Thus, suppose a physician brought to a patient suddenly attacked in the street with furious delirium, epilepsy, or coma; he does not know the individual personally, nor has he any information concerning him; he must then judge of the nature of the disease from the physiognomy of the symptoms. If the assemblage of the phenomena observed diagnosticate a lead disease, instead of bleeding the patient, which would hasten the fatal termination, more appropriate means of relief must be applied.

CHAPTER VIII.

PROGNOSIS.

LEAD encephalopathy should always be regarded as a very grave disease, however light it may appear at first; for this affection, so insidious in its progress, may suddenly present itself with a train of frightful symptoms, wholly unexpected. And as this affection is often mortal, there is always cause for fear as to its issue. The kind of accidents which present themselves should vary the prognosis. The result of the analysis of all the observations of encephalopathy, published at the present day, is, that the delirious form is the least serious, and that the comatose is much less dangerous than the convulsive, or rather, epileptic. For convulsions, partial and general, not epileptiform, often terminate happily. The union of delirium, coma, and convulsions, often announce a fatal termination.

COMPARATIVE TABLE

OF THE CASES OF CURE, AND DEATH, IN THE DIFFERENT FORMS OF LEAD
ENCEPHALOPATHY.

Observations of Authors.

	Number of Cures.	Number of Deaths.
1. Delirious form,	14	15
2. Comatose form,	2	5
3. Convulsive form, (Convulsions 4, Epilepsy 3,) 7	7	25
4. Union of the three forms,	5	16
	<hr/> 28	<hr/> 61

Observations of Tanquerel.

1. Delirious form,	16	9
2. Comatose form,	3	3
3. Convulsive form, (Convulsions 5, Epilepsy 7,) 12	12	9
4. Union of the three forms,	25	9
	<hr/> 56	<hr/> 16

According to the statements of authors, death is the rule, and cure the exception, a result entirely opposite to that of Tanquerel. The difference of mortality which exists between these two statements, arises, probably, from the mode of treatment employed, and, perhaps also, from the attention of authors not being sufficiently fixed by the symptoms of encephalopathy when it terminated by a return to health. They have not recorded any observations with a happy termination, in the cerebral lead disease. Tanquerel thinks this difference of mortality is not accidental. Lead delirium, when it is remittent, is little dangerous, it does not last long, or endanger the life of the patient. Tranquil delirium alone does not cause such serious uneasiness as furious delirium. When this last shows itself in fits, at short intervals, and an inexhaustible talking accompanies it, and lasts during the interval, then the danger is imminent. The patient may suddenly fall into an extreme drowsiness, which announces death to be near.

The most profound coma; the first variety mentioned, is almost always mortal. The patient never awakes. That which is accompanied by *sub-delirium* is much less dangerous. The patient loses his reason, but regains it by degrees.

Partial or general convulsions have never, by themselves alone, produced death. Epilepsy, on the contrary, is always attended with the greatest danger. The longer and more frequent the

attacks, the sooner will death occur. If the attacks, are followed by a comatose state, it is a sad circumstance; the danger is very imminent, if respiration become unequal, plaintive, noisy, or stertorous, and if, at the same time, the patient "*smokes the pipe*." When epilepsy succeeds delirium, it may be hoped that the disease will terminate in health.

The union of delirium, convulsions, and coma, is much more dangerous than either of these three forms alone. It is especially in these circumstances that death occurs. When encephalopathy has commenced with delirium, followed by epilepsy, then by coma, and the patient passes from one state to another, without any interval, death is generally the result. When, on the contrary, in the patient who has passed one or many times through the delirious, comatose, and convulsive forms, delirium predominates, or exists alone, after three or four days from the commencement of the disease, there is some hope of saving him. Usually, new fits of epilepsy do not appear; sometimes the patient succumbs with asphyxy during repeated attacks of epilepsy. In a small number of cases, the disease was characterized by extreme violence, not producing death; in this case, it may be said, "*ubi vita, ibi spes*."

In these cases, it is surprising to see patients, considered as hopeless, returning to health. In one case, this unexpected amelioration existed with an abundant epistaxis, which was soon followed by a profuse hemorrhage. In general, the prognostic is more favorable, in proportion as the patient struggles a longer time against the three principal accidents of the cerebral lead disease. Thus it is seldom that he succumbs after the sixth or seventh day; in the great majority of cases, the fatal termination happens in the two or three first days, and even hours, which follow the attack; there is then no reason for hope till the patient has passed these limits.

Sex, constitution, and temperament, do not seem to exercise any morbid influence upon the disease. It is not so with habitual intemperance; this circumstance appears to add infinitely to the danger of the disease. Is it not observed, every day, that acute diseases, supervening during intoxication, are often mortal? Of seventy-two cases of encephalopathy, sixteen of which were fatal, eight patients were, more or less, decidedly addicted to drinking; whilst among those cured, some, apparently more seriously affected than the first, have, nevertheless, survived; but these used alcoholic liquors moderately.

Tanquerel has not observed, that primary encephalopathy, accompanied or not by other lead diseases, is either more or less serious than that which is associated with, or consecutive to, other forms of lead poisoning.

Lead encephalopathy is one of the most serious and fatal diseases. The violence of its symptoms, and the sudden irregularity of its physiognomy, sometimes benign, sometimes grave, should cause it to be considered, as one of the affections most liable to deceive the expectations and hopes of the physician. It is one of those affections, the danger of which is all that can be told by the physician, without his being able often to determine the favorable or unfavorable termination.

CHAPTER IX.

ANATOMICAL ALTERATIONS, CHEMICAL RESEARCHES, SEAT AND NATURE.

THE physician should always try to account for the morbid functional phenomena that he observes, and to find a material or positive relation between cause and effect. It is not then astonishing, that some observers have repeatedly endeavored to find, in individuals who died of lead encephalopathy, material lesions, capable of explaining all this formidable assemblage of symptoms.

Reviewing all the recorded facts, and uniting all the observations of Tanquerel and other authors, it appears on the one part, that there were, 1, twenty-one cases, where was found a flattening, a shrinking of the cerebral convolutions with increase or diminution of cohesion of the cerebral pulp, and of the size of the encephalon; 2, nineteen cases in which the cerebral substance was found of a yellow color. Such are the facts of lead encephalopathy, in which it has been tried to find anatomical alterations in the before mentioned lesions.

On the other hand, thirty-two cases of lead encephalopathy, the autopsy of which revealed no remarkable lesion of the nervous system, should be opposed to the observations of the

first category. In these thirty-two cases, there has only been noticed sometimes slight, serous infiltration, a sanguine injection of the meninges, a diminution of consistence, especially of the white cerebral substance, without change of color or any discoloration of the brain.

The opinion of those physicians, who, not relying upon any convincing fact, have seen in lead encephalopathy only encephalitis, or meningitis, has already been refuted. The authors should have fortified their opinion with a series of proofs, more multiplied, in proportion as they alone have been so fortunate as to find such alterations. As to the shrinking and flattening of the cerebral convolutions, these lesions deserve a serious examination, for they have been noticed by numerous and skilful observers, and consequently they are worthy of the highest credence.

The first question which presents itself, relative to this anatomical lesion, is this. Do the shrinking and flattening of the convolutions constitute hypertrophy of the brain? The idea of hypertrophy of an organ, suggests an increase of the number and induration of the particles. Now, in some cases of shrinking of the cerebral convolutions, there was increase of the volume and consistency of the encephalon; here one might affirm that there was hypertrophy. But when the flattening of the cerebral convolutions co-exists with a diminution of the volume of the encephalon, it can no longer be said, that there is hypertrophy; far from it, it seems there is atrophy, or at least, a simple retraction of the cerebral mass within itself, which causes these convolutions to be strongly bound to each other.

In the case of the increase of volume, and diminution of consistence of the cerebral pulp, it cannot be said that there is hypertrophy. Thus the shrinking of the cerebral convolutions may exist in very different anatomical conditions. But are these cerebral alterations secondary accidents? Tanquerel answers in the affirmative.

What shall be thought of these alterations? It must first be remarked, that these different lesions have been observed in consequence of all the forms of lead encephalopathy. But some authors have not seen them, except in cases of lead epilepsy. The increase of the volume of the brain is not the effect of a serous infiltration, for the ventricles are usually void, and even shrunk up; neither does it depend upon a considerable sanguine

congestion, since the cerebral pulp, devoid of blood in many cases, offers in others only a few dots.

Now if it is considered with what rapidity the disease declares itself, and pursues its course, it will be acknowledged that there is not so much an increase of the number of molecules as a sort of turgescence or puffing up, which may easily be explained by the organization of the cerebral tissue, and the violence of the symptoms which have disturbed this organ. After this explanation, it may also be easily conceived why, in certain cases of violent encephalopathy, there is cerebral hypertrophy, whilst it is not observed in other cases where these accidents have been less intense. Tanquerel is persuaded that in individuals attacked with encephalopathy terminating in health, there is no cerebral hypertrophy.

Tanquerel believes that these derangements, such as hypertrophy, &c., are the result or effect of the cerebral difficulties which constitute encephalopathy. The earthy yellow of the substance of the brain may be regarded only as an accident belonging to one of the characteristic phenomena of the primary effects. It denotes the presence of lead in the brain. As to the other anatomical alterations, they differ so much among themselves, in the various cases cited by authors, that it is impossible to attribute them to the action of the same cause.

Often no perceptible lesion is found in the nervous system of individuals who have succumbed to lead encephalopathy. In certain cases, there are observed some consecutive alterations which are produced by the symptoms of this malady, and which are insufficient to account for the phenomena observed during life.*

CHEMICAL RESEARCHES.

Has chemical analysis detected lead in the brain? In two patients, who died of encephalopathy, Devergie and Guibort found in the brain a notable quantity of lead. The processes of these chemists were different. Now, as the delicate analysis of the brain by Vauquelin traced no lead in that organ, it is a fair

* See Note in the chapter on Anatomical Alterations in Paralysis, for an account of the appearances of the brain. — S. L. D.

inference, that the lead discovered by Devergie and Guibort had been absorbed during life, and had caused encephalopathy.

Gluck, an expert micrographist, examined the brain analyzed by Guibort. He observed many places in the white substance of the brain, both on the surface and in its substance, where the tubes discovered by Ehxenberg appeared shrunk, in other places these were well defined. The blood exhibited its normal character.

SEAT AND NATURE.

If, to prove the existence of any disease in an organ, it was necessary to show it by dissection, there would be little to say on this portion of the chapter. But in medicine, there is another way of proceeding to discover in what part of the body any internal disorder is seated; this way, although less accurate than the first, is conformable to reason, since it is a consequence of the laws of physiology.

Pathological anatomy, which has shed so much light on the phlegmasiæ and the organic affections, has, as yet, taught nothing satisfactory and constant concerning lead encephalopathy, probably, because the lesions, which produce this disease, are not appreciable by our senses. But no one can hesitate to regard the brain as the diseased organ; nosology and physiology naturally suggest this thought.

When any profound derangement is manifested in the functions of an organ, it is customary to consider the organ as itself diseased, and what reason naturally suggests, cadaveric inspection almost always confirms. Let any one now recall the symptoms which belong to lead encephalopathy, and he will be able to establish the seat of the alteration which it causes in the encephalon.

But, the brain being sound, the phenomena of thought and the actions of locomotion are developed in regular order. In lead encephalopathy, there is nothing of all this; there is no feeling, or at least only traces of it, perceptions and ideas are annihilated or perverted, the locomotive functions have acquired an extraordinary exaltation, or are blunted. It is not necessary to recognise the existence of a general disorder in the encephalic mass. The conclusions rest upon the most simple facts of physiology. It would be, without doubt, very interesting to know if the different forms of encephalopathy correspond to lesions of the brain

in different parts, but owing to the absence of constant anatomical lesions, there is great want of information on this subject.

Now that it is known that lead encephalopathy has its seat in the encephalon, the nature of this disease remains to be determined, to indicate in what part of the nosological table it should be placed. Encephalopathy is an acute disease; the development, succession, and intensity of the symptoms which characterize it, all announce an affection which will terminate in a short time.

It is impossible to consider as inflammatory an acute affection, which, during life, is not accompanied by fever, often remittent in its progress, appearing and disappearing suddenly without cause, and sometimes abruptly recidivating after apparent health, for one or many weeks. It is not thus that an inflammation progresses. Autopsy does not always discover an alteration of the tissue; and in cases where there is a lesion of the cerebral pulp, it should by no means be considered as the result of an inflammation. The discussion in this chapter, relative to the part that hypertrophy of the brain enacts in lead encephalopathy, excuses a return to this subject. It is sufficient to say here, that the cerebral lead disease is not the effect of hypertrophy of the encephalic mass; this conclusion embraces the other organic alterations mentioned before.

Some physicians, ancient as well as modern, have wished to explain the nature and seat of the lead cerebral accidents, by saying, that they are the result of the sympathetic action of colic upon the brain. But, in cases where the abdominal disease does not exist, by virtue of what sympathy does the cerebral affection appear? Then, the symptoms in the abdomen, in individuals affected with lead encephalopathy, are often lighter than in other patients, who experience nothing abnormal in the head. When colic has disappeared, and the cerebral lead disease remains, the source of sympathy is exhausted. It is by direct action upon the brain, that the lead particles produce the symptoms of lead encephalopathy. But all poisons introduced into the system, necessarily pass into the circulation, to show their deleterious influence upon the nervous system. There is, then, at once a mixture or poisoning of the blood with lead. The nature of the impression of lead upon the encephalon, the mode by which this disease is produced in whatever form it appears, the state of the altered functions, all these completely evade investigation.

The action of poisons and deleterious gases upon the system is also demonstrated, but is as inexplicable. How does the anarcotic poison produce coma, &c? All that can now be said is, that this disease consists in a specific, morbid modification of all the encephalic nervous system, which is perceptible by the assemblage of the symptoms, and not by the unknown cerebral alteration; in a word, lead encephalopathy should be classed with poisoning, or neuroses from a specific cause.

CHAPTER X.

TREATMENT.

To establish with certainty a rational treatment of lead encephalopathy, it would be necessary to be acquainted with its nature. In the present state of science, pathological anatomy does not afford such information. Concerning the organic lesions, there are some almost negative characters, which, united to the functional derangement, forbid the use of antiphlogistics, but do not in any way indicate the mode of treatment that should be substituted for them. The physician has then been obliged to recur to experience, to observe the progress of the favorable termination of the affection, to promote this termination by different measures, and to compare their results. As has already been proved, a very great number of observations of lead cerebral accidents recorded by authors, terminated in death. Some physicians affirm that this fatal termination always takes place, whatever treatment they employ. And an infinite variety of measures have been employed by these observers. But it should be here remarked, that the attention of authors has been especially fixed upon the convulsive form of lead encephalopathy. Tanquerel has had opportunity to observe the effect of many methods used against the different forms of lead encephalopathy.

Among thirty-four patients, eight were affected with the delirious form, two with the comatose, and twenty-four with all the other forms united, delirium, coma, convulsions; to these no

truly active treatment was opposed. But among all those individuals affected with such violent accidents, one only succumbed. Tanquerel observed these happy results, in the practice of Frayer, who was induced to prescribe these measures, on account of the frequent deaths he observed when more active treatment was directed against lead encephalopathy. He thinks it best to guard against an increase of troubles in the encephalon, and for this reason, does not employ more energetic measures.

It has been thought, *a priori* it is true, and also after the wonders that some authors say have resulted from this treatment in *delirium tremens*, that opium might be employed with advantage in the disease now under consideration. Stoll thought he proved the efficacy of opium in a patient who had a very serious lead colic, accompanied with frequent vomiting, and delirium; three profuse bleedings produced no effect, but opium immediately re-established his reason.

To six patients attacked with lead encephalopathy in the delirious form, opium was administered in the following manner: The first day, the patient took from eight to twenty drops of laudanum, in a potion in the morning, and as much in a clyster in the evening. The following days, the dose was increased, giving at last one or two drachms. A little narcotism need not be feared, it is favorable to the cure. As to the rest, it has already been proved, that opium has not the same inconveniences in lead diseases, as in other affections; it does not so quickly intoxicate the patients, or so easily produce wakefulness or nocturnal fears, &c. Of these six patients, four succumbed. Two were cured, but did not become rational sooner than those individuals, whose disease had been left to the efforts of nature alone.

Lead delirium might seem to some physicians to require bleeding. Tanquerel would forewarn them, that he has seen bleeding in four cases, followed by redoubled cerebral accidents. And even in cases where, in consequence of furious delirium, the redness of the face and eyes might cause one to suspect a cerebral congestion, depletion seemed much more advisable. External revulsives are the means which reason suggests to combat cerebral accidents. Large vesicatories on the shaved scalp, and applications of ice to the head have both been prescribed, without marked success. Four patients were subjected to this treatment, two succumbed. Opium has been regarded as dangerous

in the convulsive form of lead encephalopathy, it was tried in four cases without any success; two of the individuals succumbed, notwithstanding large doses.

The treatment of the "Charity," oil of croton tiglium, which may in this case be considered as an internal revulsive treatment, sulphuric lemonade, indeed nearly all the measures used against colic, were tried upon twenty-one patients; not one of them had a positive influence upon the progress of the disease; six of the patients died, and the others recovered their health no sooner than the individuals, whose disease had been opposed by no energetic measures.

One patient took sulphate of quinine without success. Valerian was administered once in ptisans, in potions, in clysters, but without any effect. Finally, attempts were made to act upon the nervous system by aid of one of its great modifiers, cold affusions; this method was employed three times; one patient succumbed, two were cured, but not till many days after the cessation of the administration of this remedy. In administering the affusion, choose the interval of furious delirium, several strong men should hold the patient in the bath for two or three minutes; the attacks did not not cease after this remedy.

At present, the best means known for preventing the fatal termination of encephalopathy is the expectant method. The physician who witnesses such violent accidents on the brain, with difficulty resists the desire of prescribing some treatment, in hopes that it will do no harm, and may perhaps prevent a fatal termination; it is painful for him to fold his arms before the disease, but experience is the greatest of masters; the facts referred to are sufficiently conclusive, to persuade every practitioner, that the best mode of treatment, to oppose to one of the most formidable diseases to which man is subject, lead encephalopathy, is that pursued at the "Charity" by Rayer, that is, the expectant method, of which diet and diluted drinks form the base.

PART FIFTH.

PRESERVATIVE TREATMENT.

PRESERVATIVE TREATMENT, OR MEANS EMPLOYED TO GUARD AGAINST LEAD DISEASES.

For many years, society has been moved at the recital of the many grave diseases, which so often, and so cruelly attack a large portion of that class, who labor in lead preparations for the necessities and conveniences of life. For twenty years, d'Arcet, Parent du Châtelet, and others, have, by their researches and writings, rendered nearly all the other professions safe; they have not yet undertaken the prophylactic of those in which lead preparations are used, though more numerous and more dangerous.

But authority, sovereign guardian of the public health, has demanded of scientific bodies, what precautions should be used, to render the white lead workers less liable to lead diseases. The Board of Health of Paris, through its learned reporter, Chevallier, applied to Tanquerel. He has not limited his preservative researches to a single trade, in which lead was used; he has extended them to all, so that all classes of workmen who handle lead, and its different compounds, may participate in the benefit of his labors.

With the object of establishing some preservative means against these affections, no pains have been spared that could throw light upon this subject. If the parties most interested do not place confidence in the counsels of his experience, they risk their health and even lives. If, on the contrary, they will take

the precautions pointed out by Tanquerel, which are very simple, and not expensive, they will brave with impunity dangers to which their predecessors fell victims.

Lead diseases should be regarded as most frequent and serious, for they sacrifice the health and even lives of a great many individuals. It is then a duty to prevent, if possible, the development of such affections. It is evident that the base of the prophylactic means used against lead diseases should be founded upon a knowledge of their causes. How shall the passage of the poison be closed, unless it is known where and how it enters the system?

To understand the advice given, it will be necessary to recall the different circumstances in which the workmen contracted lead diseases. (See Causes.) It will be remembered, that workmen usually contract lead diseases, because they breathe or swallow the air mixed with lead particles, which they disseminate in the atmosphere during their labors. This dissemination, and the penetration of the poison into the digestive and respiratory organs must be prevented.

Preservative treatment borrows its means of action from hygiene, and medicine; it is general or partial, that is, it is applicable to all trades in which lead is used, though each requires some peculiar prophylactic rules.

GENERAL PRESERVATIVE MEANS.

Hygienic Means.

The first, and most important general rule to establish, is the following: the workmen must be placed in such circumstances that they shall neither breathe or swallow particles or emanations of lead, although in an atmosphere charged with particles of this poison.

Ventilation. — To act upon this rule, the workshop must be large, and constructed in such a manner that currents of air passing in every direction may carry out the disseminated lead particles. This change of air by currents may be obtained in many ways; but the least expensive and most efficacious are the ventilating furnaces of d'Arcet, producing currents by rarefaction of the air, a principle well and long known, and this purpose is effected even by the ordinary fireplace and chimney.

This well known means, applied for a long time to the ventilation of galleries of mines, and sometimes proposed for renewing the air in hospitals, and other places, has produced wonders in the lead establishments. This system of forced and continued ventilation, should be arranged in different ways, according to the trade of the workshops which it is desired to ventilate.

Ventilation should be employed and continued as long as sight, smell, and taste, which are excellent indicators, discover any particles of lead in the workshop. The two white lead factories at Pecq were not equally unhealthy; one of them was less airy than the other; the workmen left it diseased after forty days' labor; whilst in the other, situated more favorably for renewing the air, the men were affected only after fifty-eight days.

Water. — Water is an excellent means for preventing the dissemination of lead particles; in all trades where the workmen handle lead under water, it preserves them from lead diseases. It is also useful to wet the floor of the workshop with water, or to spread upon it damp sawdust, to prevent the dissemination of lead dust in the air.

Sponges. — The workmen should be required to apply to the mouth and nostrils, sponges wet with water, or any other appropriate liquid, which shall permit them to breathe freely, and prevent the pulverized lead particles from penetrating the digestive and respiratory passages. Care must be taken, two or three times a day, to clean and free these sponges from the lead dust concealed in them.

An example of what these precautions may do, towards closing the respiratory organs against the entrance of lead, may be taken from the following fact. It was noticed, that two workmen, employed in grinding white lead, were attacked every five or six months with lead colic; they were required when at work to cover their mouths and noses with wet sponges. For the three years that these measures have been used, these workmen have not been subject to colic or any other lead disease. These sponges must be of fine and close grain, and large enough at the base to receive the nose, mouth and chin. To prevent all direct communication of the external air to the mouth, by the holes of the sponge, it is necessary to close with threads, the largest eyes or holes, and those which allow the light to pass through, by sewing on other pieces of sponge; in this manner

the apparatus can be made of any form. It is kept in place by being tied on to the face by strings around the head.

To preserve the eyes from the contact of lead particles, spectacles may be worn, with glasses of large diameter, set in a sponge worn like a mask. It is well to moisten the sponges with weak sulphuric acid; this removes the lead from the air which passes through them; it becomes sulphate, insoluble.*

Masks.—Instead of simple moist sponges, to prevent the lead from penetrating the digestive and respiratory organs, a leather mask, with glass eyes, can be used, with an opening for the mouth, where a sponge may be placed.

Washing the Mouth and Teeth.—In the evening and morning, it would be well for the workmen to cleanse the teeth and mouth with pulverized charcoal; this practice prevents the absorption of lead by the mucous membrane of the mouth, and will free the teeth and gums from the sulphuret of lead, which is so easily deposited upon their surface. Some workmen experience relapses, when they might, by the aid of this dentifrice, make the poison disappear from their mouths.

Meals.—It may be remembered that many examples have been mentioned of lead diseases developed in workmen, who had cooked or eaten their food in the workshops where they labored, and disseminated lead preparations. It is, then, of the highest importance to take the food out of the place for working. In some establishments, workmen, who drink water exposed to absorbing part of the air charged with lead emanations, are attacked with lead colic in consequence of such drink. The workmen ought never to drink such water.

Cleanliness.—Cleanliness is essential to the health of the workmen whose epidermis is often impregnated with lead preparations. If they neglect to wash their hands carefully before eating, the food, coming in contact with the poison which covers them, carries particles of lead to the digestive organs. Sometimes the lead adheres strongly to the epidermis, then simple water washing is not sufficient; there must be a second water or sulphuret of potassium to remove the lead.

* Meillet, (*Chemist*, vol. vi.,) has proposed moistening the sponges with hydrosulphuret of soda, which will thus act chemically and mechanically.—S. L. D.

Baths.— Though all the facts related prove that the skin does not absorb a sufficient quantity of lead to produce lead diseases, but from fear that a small quantity of the poison absorbed in this way may unite with larger quantities absorbed in other ways, and so develope these affections, it is best that all workmen who labor in lead and reduce it to powder, should often use baths of lukewarm water, and at intervals sulphurous water, to which soapy lotions may be added with much advantage.

Gloves.— Some workmen wear gloves at their work, but they have no preservative influence. They are a troublesome and illusory means.

Garments.— To prevent the absorption by the skin of the lead particles which attach to the garments of the workmen, they should wear, while at work, an oil-cloth blouse, which covers them from head to foot. When they leave the workshops to go to their meals, or dwellings, they should lay aside this garment. It has been thought that cotton garments were preferable to woollen, because of the facility with which garments made of this last material allow a passage for the dust. But these pretended preservative means have not yet produced any positively good result.

Intemperance.— In the chapters upon the *causes* of lead diseases, the influence of alcoholic excess, alimentation and dissipation upon these diseases was mentioned. The workmen should avoid all irregularity and excess in eating and drinking. How many times has an individual, habitually temperate, in consequence of a *single carouse*, been attacked with painful, sometimes mortal diseases, or which, at least, rendered them infirm in health. When the workmen have not sufficient control over themselves to conquer their unfortunate inclinations, they should leave their trade.

Working before eating.— Many masters of lead factories having remarked that those who worked before eating were diseased sooner than others, it is recommended to the workmen to eat before commencing their labor.

Milk.— Milk taken as food and drink often produces good effects. Many workmen are preserved from lead diseases, or considerably avoid the attacks by an habitual milk diet. But it should always be used warm, or luke-warm, for if taken cold it may contribute to the development of some colics which

themselves favor the action of lead upon the abdominal organs.*

Lard. — Dehaen and Christison advise the use of fat food, which they regard as a counter poison of lead.†

Kind of Food. — It has been noticed, that workmen who can obtain an abundant and substantial nourishment, composed of meat and vegetables, were saved from the pain experienced by those fed upon a small quantity and bad quality of vegetable and farinaceous food, such as kidney beans, potatoes, &c. The workmen should always be well fed. Most of them are well paid for their day's work; this money some employ in procuring nourishing food, by which their health is preserved; and do not, like others, give themselves up to all kinds of excess.

Position, or Situation of the Factories. — The proximity of lead factories may have a bad effect upon the neighboring houses. A decree of Dec. 13, 1810, placed them in the first class of unhealthy manufactories. In general it is by the modifications which they determine in the air, that these establishments render the neighboring houses unhealthy. Lead poisons are carried to them by currents of air, and sometimes produce diseases. But it must be remarked, that the pulverized particles of lead from the factories, seldom escape in a sufficiently concentrated mass to produce accidents upon the persons in the surrounding houses; they are also too heavy to be carried far, at least without a very high wind.

Tanquerel also agrees with Parent du Châtelet, that the inhabitants of the places near these factories, much exaggerate the

* In a communication by Dr. Ewick, of Barmen, (*Journ. de Chim. Méd.* Decem. 1847,) it is stated that in the white lead works in that place, producing 2500 lbs. per week, the five men who constantly work there use no ardent spirits, but take daily a quart of new milk, a pint in the morning, the remainder in the course of the afternoon, unboiled. This, with great attention to cleanliness, has prevented, for three years, any appearance among them of lead diseases. They exhibit, on the contrary, the appearance of health and vigor. — S. L. D.

† At a meeting of the London Med. Soc. Dec. 6, 1846, Dr. Willshire, of the Surrey Dispensary, said, that in the two white lead factories in that vicinity, the women who cleaned the lead pots were most liable to colic. All hands are excessively untidy and negligent of cleanliness. Dr. W. attributes much of the ill effects of lead to this cause, though fat pork made a large part of the food of the workmen. The use of fat pork and cheese is said to have been first proposed as a preventive of lead disease by Dr. Hamilton, of Lynn, Eng. — S. L. D.

inconveniences of them, though they may be indeed perfectly harmless. But the lead factories should be built as far as possible from private dwellings. No chimney coming from a lead workshop should communicate with the chimney belonging to a house.

It is best that manufactories of lead should be established upon an elevated situation, exposed to all winds. The most injurious position to the health of the workmen would be the narrow passages of a mountain or valley.

Medical Means.

Medicine teaches some precautions or means of protection from the attacks of lead diseases.

Sulphuric Acid Lemonade. — One or two bottles of sulphuric lemonade were taken per day, by fifty-four individuals living in a pulverulent lead atmosphere. They were the white lead workers of Courbevoie and Pecq, but this means has not prevented those individuals from being attacked with colic and other lead diseases. The duration of their abode in this establishment, was neither greater or less than that of other workmen, who did not use these drinks. Many of these men have been obliged to abandon the use of sulphuric lemonade. This treatment occasions heat in the epigastrium, retching, and vomiting.

But lemonade was prescribed according to the formula of Gendrin; three quarts of water, a drachm and a half of the strongest sulphuric acid with some ounces of powdered sugar. Sixty-five workmen of the white lead factory of Clichy, who have used, under the direction of Gendrin, sulphuric lemonade, and who have been brought to the "Charity," to be treated for different lead diseases, have been taken sick, on an average, two days sooner than sixty-five workmen of the same establishment, who had not used sulphuric lemonade.

The workmen and masters at Clichy are so well satisfied of the inefficiency of sulphuric lemonade, that they no longer wish to use it.

Sulphuric lemonade, then, is not a preservative against lead diseases. The entirely chemical idea which suggested the use of sulphuric lemonade is certainly ingenious. It was hoped, by this means, to transform the lead into an insoluble salt, and thus

render its absorption impossible, but the hopes to which the chemical theory gave rise, have not, unfortunately, been realized.*

Lemonade of Sulphuretted Hydrogen.—Twelve workmen, from one of the white lead factories of Pecq, were treated with a pint per day of sulphuretted hydrogen lemonade, composed according to the prescription of Chevallier, viz.: take nineteen quarts of water, add to it one quart of water saturated with hydro-sulphuric acid, in which dissolve twelve grains of carbonate of soda. Replace this drink by another, which is made by taking five grains of sulphuret of potash dissolved in a quart of water. Not one of these workmen were exempt from lead diseases; they were attacked three days later than twelve other workmen of the same establishment who did not use this drink.

This slight difference of time does not warrant the use of this means as preservative, notwithstanding the authority of Chevallier, who has related some facts tending to prove the efficacy of these sulphurous waters. The taste and disagreeable odor of this drink prevent the workmen from using it. Great persuasion was necessary to induce these twelve workmen to submit to this treatment.

Lemonade of Nitric Acid.—Grisolle made four experiments in one of the white lead factories of Pecq, with nitric lemonade. The four workmen who drank this ptisan were attacked fifteen days sooner than those who made no use of it.

Tanquerel regards even these mineral drinks rather as the means of exercising a fatal action upon the workmen, than as preservative measures; for their long continued use finally deranges and weakens the digestive passages, as has already been mentioned. This results in facilitating the deleterious action of lead upon the organs of the abdomen.

Tobacco.—The use of tobacco, recommended by Henkel and Hoffman, has been regarded as a preservative from lead colic. Three red lead workers of Clichy were affected with lead diseases nearly every month; Tanquerel advised them to chew tobacco freely, when out of the establishment; one of them was able to work six weeks without an attack; two others remained,

* See Appendix. Tanquerel's views are contradicted by the larger experience of others. — S. L. D.

one five weeks, the other forty-two days, were quite well at the factory.

It has been remarked, that the workmen who smoked or chewed tobacco, did not have their teeth and gums covered with so great a quantity of sulphuret of lead as their companions, who did not use tobacco. Some even had no trace of sulphuret of lead in the mouth; many of these individuals have been less often attacked with lead diseases than others.

All these facts seem to demonstrate that tobacco smoked or chewed, prevents, in a small degree, the absorption of lead by the superior part of the digestive and respiratory passages. Tanquerel, therefore, recommends the use of this preservative means, but he has not remarked that tobacco so taken removed the danger.

Purgatives. — The workmen and masters of the shops have been advised to use purgatives every fifteen or eighteen days, such as Sedlitz water; jalap, a dose of half a drachm; croton oil, one drop. This measure has in many cases been successful; the use of it cannot be too much recommended.

Cessation from Work. — If, notwithstanding the employment of these preservative means, the workman has absorbed lead particles, he must, as soon as the signs of absorption are manifested, immediately leave his work, and begin to use every possible means to free his system from the lead which may at any moment produce serious accidents.

Medical Inspector. — Such are the general means, by which, in all trades where lead is used, the attacks of lead poison may be averted or removed. These rules are easily practised, but it is to be desired, that in all the great establishments, a physician should oversee their strict execution. He might, by his presence and advice, surmount the carelessness and apathy of the parties most interested. This wish has been complied with in a great number of the factories and lead mines of France. In fact, this has been the custom in Germany since the seventeenth century.

PARTIAL PRESERVATIVE MEANS APPLICABLE TO PARTICULAR TRADES AND PRODUCTS.

House Painters.

House painters, when mixing their colors, should be in the

open air in summer, and in winter the room should be freely and constantly ventilated.

To render the scraping off as little dangerous as possible, it would be well to moisten the paint to be removed, and this should also be practised in the rubbing down with pumice stone, &c. If the pumicing be done dry, all the general means indicated to prevent breathing the lead dust should be used; and especial cleanliness, personal and general, should be the rule, particularly of washing before meals.

Substitution of Zinc for Lead in Oil Colors.

Numerous experiments have been made in France and England, to render painting healthy, by substituting for carbonate of lead, the base of nearly all oil paints, a substance whose action has no dangerous effect upon the system.

Guyton de Morveau first conceived the idea in 1781 of replacing white lead by white zinc. (*Annales des Arts et Manufactures*, an. ix. t. iv.) Parkes, and Turner, in memoirs published in England at nearly the same time, have also recommended the substitution of carbonate or oxide of zinc for lead in painting.

Vincent de Monpetit has also addressed a memorial to the Academy of Architecture, with the hope of making that adopt positively this substitution. The Academy by a committee, composed of Manduit, Bossut, Cherpitel and Antoine, adopted the ideas of Vincent. (*Ann. d'Hyg. et de Méd. lég.* t. xv.) The following are the reasons, deduced from numerous experiments repeated in different countries, and at different times, for the substitution of zinc for lead in painting:

1. Every body knows the pernicious effects of oil painting, with a base of carbonate of lead, upon the workmen who apply it; also upon those who dwell in close places where this paint is newly used. Oil paint mixed with carbonate or white of zinc, has no deleterious influence upon the workmen, or upon the inhabitants of the newly painted apartments.

2. Zinc white has a great advantage over white lead. The first of these substances is unchangeable, even by the vapors of sulphuretted hydrogen, and its different combinations, which immediately blackens all white lead paint. Zinc white mixes perfectly with all colors; it is employed alike in oil and distemper. It has been remarked, that it had the advantage of taking less oil, but that it dried less rapidly than white of lead.

If zinc white has not as brilliant a whiteness as the white of lead, on the other hand, it preserves its color a longer time than this last. Indeed, the most beautiful white of lead, is liable to be reduced to a black color by contact with any thing containing the inflammable principle.

3. Zinc white costs less than white lead. Thus, besides the reasons for their health, house painters have another great advantage in substituting zinc white for white lead.

There are numerous mines of zinc; of late years especially, the extraction of this metal has been conducted on a great scale, for the use of the arts. Zinc white is prepared in great quantities in Germany. The following method is due to Hermann; it has been inserted in the scientific journals since 1826.

Zinc, or its oxide, is treated by sulphuric acid; the solution is afterwards treated by sulphuretted hydrogen, then by hydrochlorate of lime; finally it is concentrated, to separate the sulphate of lime formed; the hydrochlorate of zinc which remains, is precipitated by the subcarbonate of soda of commerce, the precipitated carbonate of zinc is washed and dried.

Another more simple method is followed in England in different manufactories; it consists in precipitating a solution of sulphate of zinc (white vitriol) by carbonated alkali; but, as the white vitriol of commerce is impure, it is necessary to boil the solution, before precipitating it, in a vessel of copper, with zinc feathered or reduced to grains and scraps; this decomposes the metallic salts that the zinc may contain, and which would change its color, such as the sulphates of iron and of copper, of which white vitriol generally contains a certain quantity.

All the preceding assertions and experiments have been repeated and confirmed several times, under the inspection of the Royal Academy of Architecture at Paris, and the Academy of Dijon. The authentic approbation of these two celebrated societies, composed of learned persons, most capable of judging of such a matter, should excite the confidence of house painters and the public, in favor of this new white, which can have no injurious action on the health.

Tanquerel earnestly hopes, that the master painters and workmen will decide to substitute zinc white for white lead; they will then be able to work all their lives, without every moment fearing that they are injuring themselves, and they will find economy in this substitute, without in any way marring the beauty and durability of their work.

It is not astonishing, that this substitution has not been made already in painting, though it was proposed for the first time in 1781; for house painters were ignorant of the labors of the philanthropists, who had made these beautiful discoveries for rendering their occupation healthy. These discoveries, forgotten and registered with other very significant memoirs in the annals of science, have not come to the knowledge of the mass of the people. This is no longer an excuse, but it will, of course, take much time for this substitution to become general. But is it not the fate of most valuable discoveries, which have benefitted the human race, to wait a long time before men place confidence in them? But time at length sanctions what is good, conquers prejudices and interests, by opening new ways for the general good. If one did not wish to substitute zinc white for white lead in all cases, let it be tried as an experiment, to mix the first of these substances in the oil preparation, and use it, 1st, to paint the closets where hydro-sulphuric baths are administered; 2d, the seats of privies, in short, in all the places where there is a greater or less prevalence of sulphuretted hydrogen, or hydro-sulphates, which occasion the blackish gray discoloration of the paint in which white lead is mixed.

Painters of Decorations, Letters, &c.

The precautions just recommended to house painters, as a protection from lead diseases, are equally beneficial to painters of carriages and ornamental painters.

Drink adulterated with Lead Preparations.

Water Cisterns.—In some cities of Europe, as Amsterdam, the cistern water which is used is collected in reservoirs lined with lead. Serious diseases, which have supervened from the use of this water, which finally dissolves a small quantity of the lead transformed into oxide or carbonate, ought to induce the substitution of zinc for lead to line these cisterns. Then these grave diseases would not occur, for numerous experiments have lately proved the innocuous effects of zinc on the human system. (Parent du Châtelet, *Ann. d'Hyg. et de Méd. lég.*)

In some countries, lead is used to cover the roofs. Rain water dissolves some of the oxide of lead formed on the surface of the metal, and carries it into the cisterns where it is kept. From

this, accidents may possibly occur, if such water is drank. To avoid such dangers, it is better to cover the houses with slates, which do not produce any morbid phenomena.*

Vessels for the Preservation of Water.—Tanquerel disapproves entirely of the proposition made by Kerauden to line with sheet lead the vessels intended for the preservation of drinking-water for voyages. If this means for pretended preservation of the water was adopted, some very unfortunate accidents would certainly be the result.

Adulteration of Wines.

Formerly lead diseases produced by wines, softened with litharge, or white lead, were very common. Now, by the severity of the laws, the watchfulness of government, and the facility with which the inspectors detect the fraud, by chemical processes, accidents are seldom seen from this cause. The adulteration of wines for the purpose of concealing their acidity, is effected now chiefly with alum, potash, carbonate of lime. Formerly bits of lead were introduced into the casks, which there formed a small quantity of acetate of lead, which communicated a sugary taste to the wine. (Berzelius.) But this mode of adulteration is now scarcely ever met with.

Wine may contract injurious qualities, not only from the manner in which it is made, but also by the action of the vessels in which it is kept for sale.

Lead Counters for Wine Merchants.—The sellers of wine in and around Paris, being unable, on account of the immense quantity they sell, to have it in bottles, keep it in butts, and draw it up from the cellar in great wooden vessels of a peculiar form. It is from these they fill the measures for those who come to drink, as well as the bottles and other vessels which are brought to them by their customers.

The rapidity with which this is often done, and the difficulty of getting the liquid into some of the vessels, always causes some wine to be spilt; but as the smallest quantity of this drink is valuable, it is natural that the merchants should wish to collect it;

* The cases have been referred to in the chapters on Causes of Lead Diseases, from the Use of Lead Water. This subject, in connection with the use of lead pipe, is treated in the Appendix, to which the reader is referred. — S. L. D.

for this purpose they have counters of a peculiar form, which are covered with a sheet of lead. By this means, what falls upon the counter is carried into a receptacle below. As this receptacle is generally only a bucket, a general mixture of wines is there collected. The use of this counter is general, and the period when it was first used by wine sellers is unknown.

But a royal ordinance, founded in 1777, upon a proposition of a commission, composed of the two first physicians of the king, Lieutaud and Lassone, Mocquer, physician of the faculty of Paris, and young Cadet, master in pharmacy, proscribed the use of lead counters, founded upon what the experience of every day has proved, that solutions of lead have the most dangerous effect upon the health. It is said that wine which remains a greater or less length of time upon these counters, necessarily dissolves them in part, and as this wine is collected and sold to the people, the diseases which result from it are nearly always fatal, as they are ignorant of the cause.

They add, afterward, that it is the same with commercial tin, which cannot be employed without danger for covering counters; because of the arsenical particles it contains, and its alloy of lead, and for this reason the use of it should be excluded from private houses, and the interests of humanity require that the employment of it should be forbidden. The ordinance from which these details are extracted contains two articles: it is said, in the first, that the counters of wine merchants, *covered with lead, shall be, and are forbidden, nor shall tin be substituted for lead, under penalty of confiscation, and three hundred livres fine*; in the second, that the wine merchants shall substitute cisterns of tin plate, or sheet iron, for the sheet lead with which their counters have been covered.

Experiments carefully made by Payen prove that counters covered with pure tin occasion no accident. As to arsenic, it is united with tin in the metallic state, but, it is well known, that metallic arsenic is not poisonous, only its oxides, sulphurets, and salts, are dangerous. But tin, from its softness, and very great flexibility, cannot be used pure, it must be united with other metals which give it hardness, and in this way render it fit for all desirable uses. The only metal capable of giving to tin the proper qualities, is lead; it is then necessary to relinquish the use of counters of tin and lead. Counters covered with sheet iron give the wine so disagreeable a taste that it cannot be used as a drink.

An order of June 11, 1812, forbids wine merchants covering their counters with lead; it prescribes counters covered with tin, without any alloy of lead. This order was issued in consequence of the accidents which supervened among wine sellers, who had kept their lead counters, notwithstanding the order of 1777. Unfortunately this infraction of the law still remains among a great many wine merchants. (*Ann. d'Hyg. et de Méd. lég.* t. vii., Parent du Châtelet.)

To avoid the difficulties which result from the tin of commerce, often mixed with lead, would it not be necessary, according to the advice of the board of health of Paris, mentioned in a remarkable report of Gaultier de Claubry, to advise wine merchants to use marble counters, covered with a coating composed of white wax dissolved in spirits of turpentine, which does not change the wine in contact with it? (*Annales de Hygiène et de Méd. lég.* t. vi.)

As this coating penetrates into the marble, it may, in this manner, preserve it from the action of all the destructive agents. To apply this wax, the marble must be heated at the stove to about 212° F. and covered with wax till it is saturated.

The counter must not be used till some time after the application of the turpented wax, in order to give all the volatile and soluble parts of this solution time to dissipate by contact with the air and liquids, with which they are from time to time washed. To cover these counters, the solution of white wax in turpentine, proposed by d'Arcet, is better than the mastic *hydrofuge* advised by Gaultier de Claubry. This last is composed of one part of wax, and three of linseed oil, boiled with one tenth of its weight of litharge; but the contact of litharge with wine will produce the same accidents as lead counters. Some experiments have been made with these marble counters, and all the wine merchants who have used them have praised them.

The experiments of Vauquelin, (*Ann. d'Hyg. et de Méd. lég.* t. vi.) prove that wines and strong vinegar kept in vases composed of a compound of tin and lead, will dissolve a small quantity of this last substance; a proof that there is more than seventeen per cent. of it present.

Vessels used for measuring liquids, sanctioned by the laws, are to this day composed of tin and lead. It is surprising that these vessels are not proscribed by the government which forbade the use of tin and lead counters. Vauquelin and Fourcroy contend

that such vessels do not exercise a deleterious influence on the health of the citizens, on account of the small quantity of lead dissolved. But these chemists did not know, at the time they wrote, that if the liquid only dissolved one grain of lead, it was sufficient to produce mortal disease. In view of such certain danger, why not speedily change the substance which composes these measuring vessels?

Adulteration of Cider and Beer.—Cider, perry, and especially beer, are also adulterated, rarely it is true, by lead preparations, such as litharge, for the purpose of giving them a sweet taste. These frauds cannot be too carefully watched. Tanquerel observed one as late as 1837, which proves that these adulterations are made, notwithstanding the severity of the laws.

In some parts of England, particularly in Devonshire, the bad custom prevailed of joining the different parts of the cider press with hoops of lead. The difficulties, according to Baker, formerly produced, caused these hoops of lead to be forbidden.

Adulteration of Alcoholic Liquors.—Alcoholic liquors are sometimes adulterated with lead preparations. It often happens, by the little care taken of the vessels used for manufacturing these liquors, or by the bad tinning of those in which they are kept for some time, that they are often found to contain salts of lead, in a quantity sufficient to produce real diseases, the cause of which has been revealed by chemical analysis. The best way to prevent a recurrence of such accidents would be to keep these liquors in earthen vessels, as is done in Brittany and in Normandy.

Adulteration of Orange Flower Water.—It seems that orange flower water, coming from foreign countries, often contains litharge and salts of lead.

Orange flower water from Grasse, sent to the druggists of Paris, often contains acetate of lead, from one to sixteen grains per quart. This liquor is sent in very small copper vessels lined with impure tinning; in order to make these vessels stand, they are accustomed to apply at the bottom a very thick layer of solder which contains much lead.

But when the orange flower water is distilled too quickly, it becomes slightly acid, this acetic acid increases by keeping, and every moment being in contact with a tinning which contains lead, it is soon saturated with it. Such is the origin of acetate of lead in orange flower water. (*Ann d'Hyg. et de Méd. lég.* t. iv. Labarraque et Pelletier.

With the intention of avoiding the accidents which result from the use of orange flower water thus charged, vessels of different substances have been tried, but experience has sanctioned those of copper; but it is necessary to be careful that the tinning, and the ballast placed at the bottom on the outside, should be of pure tin, for then no poisoning need be feared.*

The chemical processes, by which the adulteration of liquors by lead is discovered, being the same, they will now be pointed out in a general manner.

To discover lead, if it is in red wine, or any other colored liquid, it is discolored by animal charcoal well washed in weak hydro-chloric acid. The filtrated liquor is evaporated in a platina capsule; when it is reduced to a third part, it should be filtered again, and treated by re-agents suited to detect the aqueous solutions of lead, such as sulphuretted hydrogen, dissolved in water, hydro-sulphuric or sulphydric acid cause a discoloration brown or blackish, or a precipitate of sulphuret of lead.

Drinks adulterated by a considerable quantity of lead preparations, are of a sugary, styptic taste; those, on the contrary, which contain only a small quantity of lead, introduced from imprudence, but without intention to injure, do not occasion any peculiar taste; chemical analysis alone can discover the cause of the disease.

Food adulterated with Lead Preparations.

Formerly, it was not very rare to find lead preparations in the composition of many articles of food, such as bread, and butter. The way to discover this fraud is very easy. It is sufficient, after having incinerated the adulterated matter, to treat it with hydro-sulphuric acid; the black sulphuret of lead which results from it sufficiently indicates the source of the adulteration.

Tinning of Utensils.—Food, prepared in vessels lined with lead, or tinned with alloy in which there is an excess of this substance, has occasioned accidents which have attracted public

* The adulteration of orange flower water with lead was noticed in London a few years ago, and produced some excitement. — S. L. D.

attention, and divers orders have been published to prevent this danger.

Several chemists, among others Vauquelin and Proust, have contended, that a lining of lead and tin, however badly made, has not the injurious effects on the health that are usually attributed to it. Tanquerel thinks the views of these two chemists erroneous, as they do not rest on medical observation.

Because some food, cooked in badly tinned vessels, produced no effect upon some dogs who took it, does it follow, that it could have been used with impunity by individuals? Certainly not. Are not persons seen every day, submitted to the influence of the same morbid causes, experiencing marked effects from these causes, whilst others experience none?

If this food, so cooked, produced poison in one hundredth part only of the individuals who used it, it should be forbidden. Some examples of different lead diseases have been cited, produced by aliments prepared in vessels badly tinned, or too long used. That a coating of tin and lead should not injure the health, it is necessary that this last substance should not enter more than ten per cent. If the lead was there in very large proportion, the vinegar would easily form an hurtful acetate. The lining of vessels much used, is finally destroyed, the detached particles are mixed with the food, and introduced into the system. This tinning should be carefully renewed whenever needful, in order to prevent serious accidents. Iron, where there is no fear of the irony taste, wood, tin, brown stone, and crockery ware, porcelain, marble, and zinc, furnish excellent utensils, and may be used a long time as receptacles for food.

Lead Foil is often used in commerce to wrap different substances, as chocolate, tea, &c., to prevent the air from penetrating to them, and injuring them. The moisture of the air may incorporate some particles of the lead with these substances; it is much better to use sheets of zinc.

Bonbons. — Certain bonbons, such as sugar-plumbs, &c., are painted with colors containing white lead, red lead, and chrome yellow.

The means used to discover the lead nature of these bonbons are the same as those indicated for discovering lead in solid food. To color these bonbons, different preparations may be used, which have no deleterious influence on the health, such as cochineal, lake, carmine, Persian berries, grains of Avignon, woad, and an infinity of other vegetable colors.

Cosmetics.—White lead or carbonate of lead serves for a base to certain cosmetics or paints, the employment of which may become dangerous.

The white of Krems, or alabaster white, is a mixture of this salt with the fat of veal and virgin wax; vinegar white has the same properties, and it is necessary to use it with discretion. Some use sulphate of lead mixed with slacked lime and water to make the hair black. Orfila has performed many curious experiments upon the artificial coloring of the hair, to prove the efficacy, and at the same time the harmlessness of plumbite of lime, which is of easy application. Acetate and sub-acetate of lead dissolved, turn the hair black as soon as they are in contact with hydro-sulphuric acid. Litharge, chalk and recently slaked lime, ground and mixed exactly, form, with water, a clear liquid, which gives to the hair a beautiful black color.

All these preparations, used without precaution, that is, placed in contact with the mucous membrane of the lips, nose, eyes, &c. may produce lead disease. It is necessary to use them with great care, and so to apply them to the skin, that they will not come in contact with the mucous membranes, or where the skin is abraded.

The cream of Psyche, intended for preserving the lips, contains a considerable quantity of acetate of lead, in a mixture of oil of sweet almonds, wax, &c. The mucous membrane of the lips being a very active absorbent, there is very great danger in applying preparations of this kind; their use should be forbidden.

Lead Medicines.—The facility with which lead diseases are produced, from lead taken internally, should render physicians very careful in its use. And besides the materia medica possesses so many other substances, endowed with the same therapeutical properties as lead preparations, it seems most prudent to completely abandon the use of these medicines. The perfect harmlessness of lead medicines, as white water, &c., applied upon the skin, permits their use; but frictions, and especially the application of topicals on the skin, stripped of the epidermis, should be abandoned, as accidents have resulted from it.

Newly painted Apartments.—The instances of lead diseases, which have occurred in those individuals who have lived or slept in newly painted rooms, should warn people not to inhabit these until one or two months after the last coats of paint

have been applied, and when it has been sufficiently dried by good fires, and frequent opening of the windows, and there should be no smell of spirits of turpentine.

Besides ventilation, fire should be used; hay spread on the floor, and shut up in the painted rooms shortens the time during which these emanations are perceived. Labarraque has proved a number of times that chlorine water sprinkled on the hay succeeds still better. At one of the public offices of the Bourse, in Paris, the smell of paint having compelled the inmates to suspend their labors, the use of this means for a single night, allowed them to inhabit the room the next day, without accident. If the floor is painted, and it is feared that the chlorine water may change that, it will be sufficient according to Labarraque, to place there, during the night, plates filled with chlorine water.

Such are the different means by which men may protect themselves from lead diseases.

END OF PART FIFTH.

APPENDIX.

APPENDIX.

ON THE EXISTENCE OF LEAD AND COPPER IN THE HUMAN SYSTEM.

THE question of the existence of these metals in the human system, is of the highest interest both to pathology and legal medicine. Lead detected in the human body will not authorize the conclusion, that it has been a cause of disease or of death in cases of suspicion of poisoning. It must first be determined whether its presence is natural or accidental. This is an important distinction. Perhaps the classification pointed out as early as 1824, by the father of Organic Chemistry, Chevreul, is that best adapted to give clear views of the state in which these metals exist in the human body. In his paper, "General Considerations and Inductions relative to the Matter of Living Beings," *Journ. de Pharm.* Jan. 1844, and *Chemist.*, vol. 5, p. 104, Chevreul distinguishes three classes of immediate principles:

1. Principles absolutely essential, which may not be replaced, and life continue.
2. Principles necessary, but which may be replaced by others.
3. Principles accidental, neither essential or necessary.

In this last class it will be safest to place at present lead and copper.

Of this opinion are Chevreul and Devergie. On the other hand, Orfila, certainly of the highest authority, maintains that lead is always found in the human organs. This he calls "nor-

mal lead," a term to which Devergie objects, as conveying the idea of indispensable, and he uses the term "natural lead," that is, lead existing in, but not indispensable to, the body in the ordinary condition of life. It is certainly the better term, and Orfila uses it occasionally. But that lead and copper exist naturally is stoutly denied by MM. Danger and Flandin; the latter, well known as the opponent of Orfila, in the *Madame La Farge* case. Without entering into this controversy, facts may be appealed to, showing the very common presence of lead and copper in human organs.

If the average quantity may be approximated, then the excess which may be found in subjects who have died of lead complaints, may be considered as a true cause of disease. To detect lead, two processes have been followed by the opposite parties, the one using that first introduced by Devergie and followed with some modifications by Orfila; the other, that of Danger and Flandin. Devergie's consists essentially in drying, carbonizing, washing, and incinerating in a porcelain crucible the matter to be examined, treating this product by acids, and evaporating the solution; re-dissolution and precipitation by sulphuretted hydrogen, &c.

Flandin and Danger carbonize by sulphuric acid the animal matter, and then calcine the sulphuric charcoal, which is then to be treated as in the other mode.

The process of Devergie was introduced in 1836. Before this time, as has been shown in the body of the work, no lead had been found in the organs or excretions of lead patients. In 1836, Devergie first detected natural lead and copper in the human organs. The fact was confirmed in 1838 by Orfila, Ollivier (d'Angers), and Devergie, and his companion Harvy, and still later, in 1845, by Devergie and Boutigny. Not an instance can be found, where the examination has been carefully and skilfully made by Devergie's mode, where copper and lead have not been detected, since the fact that these metals exist naturally in human organs has been announced.

Devergie has published in the *Ann. d'Hyg. pub. et de Méd. légale*. t. xxiv., 1840, the following table of the age, sex, and condition of several subjects, whose organs he had examined, and the respective quantities of lead and copper afforded by different organs of the human system.

	LEAD SULPHATE.		COPPER SULPHATE.	
	Gram.		Gram.	
A new-born infant — Intestinal tube, . . .	0	001	.	0 001
Child eight years old — Stomach, . . .	0	004	.	0 005
“ four years old — Intestinal tube, . . .	0	025	.	0 030
Adult healthy woman — Stomach, . . .	0	020	.	0 025
Strongly calcined — Intestines, . . .	0	040	.	0 046
Gently calcined — Intestines, . . .	0	030	.	0 035
Man — Strongly calcined, “ . . .	0	025	.	0 037
Gently calcined, “ . . .	0	031	.	0 040
Gallbladder, and bile, . . .	0	003	.	0 002
Sick woman — Intestines . . .	0	010	.	0 010
“ “ — Brain, 1 lb. . . .	0	006	.	0 010

The highest range is 0.046 milligrammes of copper, and 0.040 milligrammes of lead, for the total of the organ. It must be noted, that these and the numbers in the table express the weight of the product of sulphates of the metals; hence, in the lead column, if one third is deducted, the balance is nearly the weight of the oxide of lead.

Such were the facts, when in July, 1843, Danger and Flandin came forward, and, in a report to the Academy of Medicine, denied the existence of natural, or, as they term these, physiological copper and lead. But the difference of opinion seems to be caused by the difference of their process. In fact, it is evidently quite inapplicable to the detection of lead and copper. These metals are contained in the sulphuric carbon, and were there found by Devergie, Boutigny, Barse, and Follin, who repeated the process of Flandin and Danger, and then incinerated the sulphuric carbon.

The following deductions are drawn from the facts by Devergie, in a memoir to the Academy of Medicine, 1845, (*Ann. d'Hyg.* t. xxxiii.)

1. All organs of man contain traces of copper and lead.
2. The proportion increases with age; it is small in the new born infant.
3. Prolonged sickness, where alimentation is deficient, remarkably diminishes the natural quantity of copper and lead.
4. This effect is due to the origin of the metals in the aliments.
5. Copper always exceeds the lead.

New evidence of these facts is daily accumulating. Victor Legrip (*Jour. de Chim. Méd.* May, 1847,) operating by Dever-

gie's process, finds in 500 grammes of human liver and spleen 0.0045 of copper, and 0.0027 of lead; and June 8, 1847, Orfila, in a paper read to the Academy, (*Ann. d'Hyg.* t. xxxviii, 1847,) puts among others this question:

1st. Do natural lead and copper constantly exist in the human system? He answers decidedly, yes.

But a process for detecting lead and copper and other inorganic substances in blood, more refined than any which has ever before appeared, has been recently proposed by Millon. Its simplicity is equalled only by its delicacy. It is truly an analysis of the blood *via humida*, and seems to settle forever the question before us. In this process, blood is drawn immediately from a vein into water, then introduced into a jar of chlorine gas. It immediately coagulates, becomes disorganized, a brown precipitate falls, containing all the animal or organic matter, while all the salts and inorganic matter remain in solution in the water. This separation is so complete, that the organic precipitate, incinerated in a platina capsule, leaves only so slight a trace of the salts, that it may be due to the water which moistened the coagulum, while, if the water is evaporated dry, the residuum, burnt in the combustion tube, gives only traces of organic matter, due to the minute portion held in solution by the water.

If the water is weighed before and after the separation of the coagulum, the increase of weight represents that of all the salts in a given quantity of blood, so that one may operate on a known weight of filtered liquid, as on a determined weight of blood.

Blood, examined by this process, besides silex, iron, manganese, always exhibits copper and lead. The proportions are in 100 parts of the dry residuum from evaporation of the water.

Silex, . . .	1 to 3	Lead, . . .	1.0 to 5.0
Manganese, . .	10 to 24	Copper, . . .	0.5 to 2.5

Are the lead and copper diffused generally in the blood, or confined to the sanguineous globules? M. Millon, from his experiments, decides that these metals are fixed with the iron in the globules, and share with it organization and life. (*L'Institut.* No. 372, Jan. 1848, in *Edin. Phil. Jour.* Ap. 1848.) It seems, therefore, that copper and lead exist naturally in the blood wherever that has been examined to detect these metals. Whether this fact will prove to be universally true, remains to be

proved. Whence does the blood derive these elements? The answer is obvious—from the drink and aliments. In society, where all articles of food are so liable, as has been shown in the body of this work, to come in contact with copper and lead, it is not difficult to admit the aliments are a source of these metals. But Legrip, (*Journ. de Chim. Méd.* May, 1847,) has found copper and lead in the organs of a cow, the metals here preserving the quantitative normal relation as in man; Chevreul has found copper in beef. These must have been derived from the natural food of the animals, unsophisticated, doubtless, by the artificial processes of society. This opens the question, Do vegetables naturally contain copper and lead? Numerous chemists, Bucholz and Meissner, who first noticed copper in vegetables, Gahn, Vauquelin, Berzelius, Sarzeau, who, finding copper in plants, first suggested its occurrence in man, Boutigny and others have shown the existence of copper in a great variety of plants, fruit, and grain. Its presence in wheat has long been established, and its quantity determined. From the quantity of wheat annually consumed in France, Orfila has calculated that about 8000 lbs. of copper every year enter the bowels of the inhabitants, from this source. At the meeting of the Academy of Sciences in Paris, Jany, 1848, Deschamps attempted to show that all soils contain copper as carbonate. It is dissolved by the carbonate of ammonia, and so is carried into plants.

The natural existence of lead in plants is not authenticated, but its frequent fraudulent presence in tea cannot be doubted. Whatever may be the source of the copper and lead in the organs of man in certain cases, the presence of copper naturally, in some shell-fish, as shown by Bourchardat, and very recently by Harless, in the blood of the ascidia and cephalopoda—as *Cancer pagurus*, *Acanthias zeus*, *Conger vulgaris*, *Eledone*, *Helix pomatia*, &c., shows that copper is not confined to warm-blooded animals only.

Is the quantity of lead which is found in the human system increased in lead diseases? The analysis of Devergie, of the organs of an encephalopathic subject, who had also colic and arthralgy, has been generally stated by Tanquerel in this work. The proportions are here subjoined as a part of the answer to the above question. The results are given in sulphates, as before.

	SULPHATE OF LEAD. Gram.	SULPHATE OF COPPER. Gram.
Stomach,	0.030	0.020
Lungs, traces only.		
Kidneys, 8 oz. 1 dr.	0.002	0.001
Bladder, gall, and bile,	0.004	0.001
Bladder, urinary,	0.005	0.003
Muscle, 1 lb.	0.026	0.024
Blood, 7 oz.	0.050	0.044
Teeth, incrusting matter about 2 grains,	0.001	0.000
Feces,	0.023	0.030

The numerical result for the intestines was unfortunately lost, but the quantity, so far as ascertained, was enormous, and exceeded that of the copper by seven or eight times.

These are interesting results; they show, by comparison with the preceding table, not only an increase in the amount of lead over that naturally existing, but that the normal relation between the weight of lead and copper is reversed, the lead in every case exceeding the copper except in the feces. (*Ann. d'Hyg. et Méd. lég.* t. xxiv., 1840.)

The results of Devergie have been confirmed by more recent analyses. Todd, in his practical remarks on gout and rheumatism, fever, &c., relates the case of a house painter who died in King's College Hospital. He had colic, paralysis, and cerebral disturbance, the effects of lead. On autopsy, extensive tuberculous inflammation, beginning round points as centres; in many of these, in the congestive stage, were minute blackish points, which were suspected to be lead. On chemical examination, lead was found in great quantity in the brain, and in still larger amount in the lungs. Dr. Inman, of Liverpool, found a large quantity of lead in the brain of a lead epileptic. (*Amer. Journ. Med. Sci.* vol. xi., 1846.)

Dr. Miller, at King's College, detected lead in abundance in the paralyzed extensors of the hands in a subject who died of lead epilepsy, with wrist drop. Lead has been repeatedly found in the urine of lead patients. According to Danger and Flandin, the mode of excretion of lead, when administered as medicine or poison, is by urine, but no lead has been detected in the urine of white lead workers; (Taylor.) Orfila has found lead in the liver of lead patients, and in his last paper, read to the Academy on this subject, June, 1847, (*Ann. d'Hyg. et Méd. lég.* t. xxxiii., 1847,) he establishes the fact, that lead and copper, existing naturally in

the body, may be always simply and easily distinguished from that causing disease or death.

It has been shown above by Millon, that natural lead is combined with the globuline; the analysis of the blood of a patient with lead colic by Prof. Cozzi, (*Gaz. des Hospit.* Jan. 1844,) was not only the first which showed with which of the proximate principles of blood lead was combined, but now proves that lead, as a cause of disease, is combined with a principle, viz., the albumen, distinct from that of its natural position.

It may be objected that the lead and copper found in the human body, and in plants, is derived from the apparatus or reagents of analysis. There may be some force in this as applied to lead, but it is quite certain that the glass and porcelain vessels used by chemists contain no copper. If the minutest traces of copper cannot be discovered in chemical glass, it is difficult to account, not only for its constant presence, but its uniform excess over lead, where these exist naturally. If, in lead diseases, the metal which analysis reveals is supposed to be due to the reagents and apparatus, it is remarkable in these cases that the lead should exceed the copper. It is an argument proving the purity of the tests and vessels.

It is well known that water, standing in a flint glass vessel, dissolves a portion of that lead compound, and then discolours silk or wool. (*Memoir to the Academy*, by Chevreul, *Comptes rendus*, Sept. 16, 1844.) But when it is considered that for delicate researches chemists now use glass, containing not a trace of lead, that all their reagents are prepared with scrupulous regard to purity, and that in these researches on natural lead and copper, the quantity of acids and of distilled water used in the process, is very small, drops only as it were, it is impossible to admit any other source of these metals than the organs which were subjected to analysis.

ON THE USE OF SULPHURIC ACID, AND SULPHUROUS BATHS IN LEAD DISEASES.

It will have been noticed by the reader, that Tanquerel has little confidence in these proposed chemical remedies and preventives. Like many other subjects in medicine, this is still an open question. Its proposition was received with open and decided hostility by one party. A warm dispute between Gendrin, its originator, and Tanquerel, has been roused, and each has arrayed facts and documents to show that there is but one side to this question. Without entering into this dispute, the facts may be calmly surveyed, and from these the inference may be drawn, that while the most sanguine expectations of the advocates of sulphuric lemonade have not been fully realized, yet a degree of success has attended its use, both as preventive and curative of lead diseases, which by no means allows it to be ranked as inefficacious, as is represented in this work.

Tanquerel's assertion, says Gendrin, (*Ann. d'Hyg. et Méd. lég.* t. xxvi.,) that sulphuric acid does no good, is not borne out by his own trials; for of the fifty-three patients so treated at the "Charity," twenty-seven were cured, and twenty-six others abandoned its use after three or four days' trial; certainly not a very fair trial. Gendrin affirms, that the workers at the Clichy white lead works assure him that the use of sulphuric lemonade has had among them decided good effects; and Roard, a distinguished chemist, the founder and director of the establishment at Clichy, has written Gendrin a letter, stating the names of hands, who, previously often attacked with lead colic, had, by the use of the lemonade, been working eight months without a return of this complaint. Besides this, Gendrin received letters from the overseer and hands in the lead works at Pecq, in March, 1834, bearing like testimony. The overseer had then been four months without an attack of colic, though previously he had suffered from it every twenty-five days. Three hands in the white lead works of Simon and Besançon, give similar testimony to the good effects of the use of sulphuric lemonade. Gendrin, the physician of La Pitie, in defence of his doctrine, published, in 1845, a communication in "*La*

Presse," (quoted also in the *Lancet*, May 31,) in which he affirms, that from fourteen years' experience in the hospitals of Gochin, La Pitie, and the Hotel Dieu, lead colic may be cured rapidly and surely by the use of sulphuric acid, and, what is still more important, lead diseases by this means prevented. Whatever may be the gravity of the disorder, if no cerebral disturbance has appeared, colic may be cured in six days in extreme, or in three days in slight cases, by the use of one and a half drachms of sulphuric acid in three pints of water, taken in the course of twenty-four hours. To this treatment the vigorous use of the sulphuretted bath must be added, especially where cerebral and nervous symptoms appear. As preventives, the daily use of two glasses of sulphuric lemonade, diligent washing with soap and water, changing the dress after work, and a bath two or three times a week, are recommended. If these are omitted a week, the lead disease reappears, and most surely in two or three days if the person becomes intoxicated. The use of the sulphuric lemonade has not been found, in Gendrin's practice, to induce the evils mentioned by Tanquerel, and the workmen at Clichy have used it two and a half years without inconvenience.

Gendrin has successfully treated, since 1831, between four and five hundred cases of lead colic, by sulphuric lemonade.

In confirmation of these statements, the testimony of Mr. Bennet, who for three years was the pupil and house physician of Gendrin, may be added. (*London Lancet*, April, 1846.) "During the three years I was with M. Gendrin, I saw a vast number of cases of lead colic. We had indeed, nearly always, two or three men thus affected in our wards from the carbonate of lead works at Clichy. All of these cases were treated with sulphuric acid, and I do not recollect having seen one, in which the disease proved refractory to the treatment adopted, — a case or two of confirmed paralysis excepted. The duration of the treatment, as far as I can collect from my notes, was about three days in slight cases, and six or seven in severe ones. Sometimes, the lemonade was vomited as soon as ingested; the patient was made to persevere in its use, and the stomach soon retained it." When this was the case, "the abdominal pains generally began to diminish after the first, second or third day, the constipation soon giving way naturally after they had become less intense; the sulphuric acid being the only medi-

nal agent resorted to, if we except baths. At the commencement, a sulphur bath was given," the sulphur "combining with the lead particles on the skin formed a black sulphuret." "The amount of this black incrustation is nearly incredible, — men go into the bath white, and come out nearly as black as negroes." When this incrustation is removed, by the daily use of soap and water, and vigorous use of a good stiff scrubbing brush, the bath is repeated. The black skin is renewed. The process is repeated till the skin is no longer discolored by the sulphuretted bath. Mr. Bennet observes, "this precaution is indispensable, if we wish to insure against a relapse." Patients from other Parisian hospitals, discharged as cured a few weeks previous, were admitted to La Pitie and St. Louis, having relapsed. "The sulphur bath explained at once the cause of the relapse. No patient who has suffered, and been treated for lead colic, can be considered safe, unless he has gone through the sulphur bath with a perfectly white skin."

On the action of the sulphur bath, it may be remarked, that this repeated renewal of the coat of black sulphuret, has been supposed to indicate an excretion by the skin of the lead in the system. This is to make this an emunctory organ. That while the lead remains in the skin, it is absorbed, and then carried into the circulation, is evidently true, and the discoloration being quite superficial, this thin film is removed by the action of alkaline soap and hearty scrubbing. The disappearance of the dark color is no evidence of the total removal of the thick crust, so long as the dark shade is renewable, as Mr. Bennet observes; and in confirmation of the view, that lead is not thus removed from the system by the skin, it may be stated that, according to the observation of Martin Solon, (*Ann. d'Hyg. et Méd. lég.* t. xxiv.) it is merely deposited lead, for painters, not being exposed to the dusty atmosphere of white lead works, having colic, for which a sulphur bath has been administered, followed by scrubbing, do not exhibit this renewal of the discoloration by a second bath, or, at most, only here and there a patch.

When it is considered how very reluctantly men resort to preventive measures against any form of disease, which is not actually raging as an epidemic, it is not astonishing that the advice of Gendrin has not been followed. Do men resort to vaccination without compulsion? Are not our largest manufacturers obliged to suggest, that persons intending to work

in the mills shall previously have been vaccinated? Do not school committees adopt and enforce a similar rule? Are not hundreds thus saved from small-pox, who would otherwise have taken their chance of contracting a contagious disorder? So of white lead workers. Who among them will live up to the preventive rules unless induced by an authority, which at the best is rather advisory than compulsory? Men are not generally influenced by the contingent of a possible disease, nor do they adopt often preventive rules from a sense of duty to preserve health. Hence it is not a valid argument against the theory and practice of Gendrin, that the hospital reports of lead patients show no decrease of lead diseases. It must be ascertained first how far prevention, by sulphuric lemonade, cleanliness, and regular habits, has been adopted. With these remarks let the appeal be made to facts. Chevallier (*Ann. d'Hyg. et Méd. lég.* tom. xxvi., xxvii., xxxvii.) states that facts show that the number of cases of colic is on the increase, and the number of deaths was not diminished, notwithstanding the improved modes of treatment. The whole number of cases of metallic colic in nine hospitals in Paris, in 1840, was 248, five of which were produced by copper. One hundred and fifty-two were white lead workers, and the remainder were of various other trades using or handling lead and its preparations. The result for the following years is thus stated:

		Total cases.		Deaths.	
1833	.	398	.	8	
1834	.	364	.	7	
1835	.	425	.	6	
1836	.	424	.	18	
1839	.	211	.	8	
1840	.	248	.	10	
1841	.	302	.	12	
1844	.	360	.	9	cured 244, 7 in hospital.
1845	.	475	.	17	" 458
1846	.	552	.	13	" 539

The last three years show an increasing number of cases. To what cause can be attributed the remarkable diminution in the years 1839, 1840? In the absence of evident cause, it may be supposed, that during this time the prophylactic rules of Gendrin were more strictly enforced. The disputes of the parties, it may be hoped, were not without a salutary effect, in exciting attention to this subject. It is devoutly to be wished, that the

public health may be ever benefitted by the honest differences of opinion so often occurring among the friends of science. The reader will notice that Chevallier has not reported the years 1838, 1842, and 1843. The *Gaz. Médicale*, Jan. 7, 1847, as quoted in Taylor on Poisons, Amer. ed. states that for five years (1838-42), of 1330 cases of lead disease in the Parisian hospitals, 655 were white lead workers and painters; of 341 who were workers in white lead, 55 died. Only 22 cases occurred in the five years among those who only handle lead.

In reply to the objections urged against the sulphuric lemonade, the following facts are sufficient to establish its preventive power beyond the possibility of doubt. Mr. Benson, managing director of the British white lead works, Birmingham, states, in a letter addressed to the editors of the *Lancet*, Dec. 10, 1843, (*Vol.* i. 1842-43), that colic for many years had been very frequent among the workers in that factory. All the usual preventives were enjoined, and adopted, under the care and inspection of a medical attendant employed by the company. Gloves, masks, change of clothing, great cleanliness, and mechanical removal of lead dust, as far as practicable, were used diligently, yet some cases of colic would occur. Having heard of sulphuric acid as used in France, Mr. Benson added it to the treacle beer, which was the common and abundant beverage of the workmen. This was in the summer of 1841. For some weeks no good result appeared, but persevering in the use of this sulphuric treacle beer, the cases of colic began to diminish; and from October, 1841, to the time of writing his letter, about fifteen months, not a solitary case of colic had occurred among the white lead workers in the establishment. The following is the recipe for making the beer.

Treacle 15 lbs., bruised ginger $\frac{1}{2}$ lb., water 12 gallons, yeast 1 quart, bicarb. soda $1\frac{1}{2}$ oz., oil of vitriol $1\frac{1}{2}$ oz. by weight. Boil the ginger in two gals. water, add the treacle, and the remainder of the water, hot, put the whole in a barrel, and add the yeast. When the fermentation is nearly over, add the oil of vitriol, previously mixed with eight times its weight of water, lastly the soda, dissolved in one quart of water. It is fit for use in three or four days. The soda gives briskness, and saturating one half the acid, forms sulphate of soda.

ON THE USE OF LEAD AS A CONDUIT OR RESERVOIR FOR
WATER FOR DOMESTIC PURPOSES.

Before entering on the discussion of this subject, it may be proper to state certain propositions, on which there is at the present day very little if any difference of opinion. They are conceded points on which parties have agreed.

1. Pure metallic lead is never acted on by water perfectly free from uncombined oxygen, atmospheric air, or salts.

2. Pure metallic lead is oxidated by the presence of atmospheric air in water. This oxide is absolutely dissolved by absolutely pure water.

3. The oxide of lead, formed as in (2), is acted on by carbonic or other organic and mineral acids present in water, salts of lead result, among the most common of which is carbonate of lead.

4. From the mixture of carbonate and oxide of lead, and of various saline and organic matters usually present in water, results a deposit which coats the surface of the lead.

5. This coat is more or less protective against the farther action of *that* water in which it was formed.

6. This coat is formed more or less perfectly, more or less rapidly, in different qualities of water.

That water, as naturally found, in certain conditions, dissolves lead, is undisputed. The interest which this subject should excite, depends on the fact, that lead, in continued small doses, is a slow poison. The action of water on lead has attracted little attention in France, or on the European continent. The lead arts and trades, which are there so numerous, the multiplicity of forms in which lead thus comes in contact with the animal economy, have been the chief objects of inquiry with the continental observers. They have looked more to lead wine, than to lead water, as a cause of disease; and though Tanquerel has mentioned several cases of lead colic and paralysis produced by water containing that metal, yet the aqueducts of lead which fell under his particular observation, were supplied with that quality of water, which, as will presently be shown, seems least likely to be affected by the presence of lead. In Britain,

on the contrary, the action of water on lead early attracted the notice of Baker, and Percival, and Lambe, and in later days, even down to the present, has absorbed the attention and energies of those distinguished toxicologists, Christison and Taylor, who have made an extensive and long continued series of experiments on this subject. It is the duration, united with the nearest possible approach to the usual state of a lead pipe conducting water, which stamps true value on all experiments to elucidate the action of water on lead. These conditions absent, no positive deductions can be drawn from experiments, however carefully and skilfully conducted. Even some of the results of Christison, guarded as they are, must be taken with great limitation in actual practice. The result of the entire investigations of Dr. Christison on lead for conducting water, is stated in his memoir in the *Transactions of the Royal Society of Edinburgh*, vol. xv. The conclusions of Dr. Christison, on the use of lead for transmitting water, are :

"1. Lead pipe ought not to be used for this purpose, at least where the distance is considerable, without a careful examination of the water to be transmitted.

"2. The risk of dangerous impregnation of lead is greatest in the instance of the purest water.

"3. Water which tarnishes polished lead, when left upon it a few hours, cannot safely be transmitted through lead pipes, without certain precautions. Conversely, it is probable, though not proved, that if polished lead remains untarnished or nearly so, twenty-four hours in a glass of water, the water may be safely conducted through lead pipes.

"4. Water containing less than about an 8000th of salts in solution, cannot safely be conducted in lead pipes without certain precautions.

"5. Even this proportion will prove insufficient to prevent corrosion, unless a considerable part of the saline matter consists of carbonates and sulphates, especially the former.

"6. So large a proportion as a 4000th, probably even a considerably larger proportion, will be insufficient if the salts be in a great measure muriates.

"7. In all cases, even though the composition of the water seems to bring it within the conditions of safety now stated, an attentive examination should be made of the water after it has been running a few days through the pipes, for it is not improb-

able, that other circumstances beside those hitherto ascertained may regulate the preventive influence of neutral salts.

"8. When water is judged of a kind which is likely to attack lead pipes, or when it actually flows through them impregnated with lead, a remedy may be found, either in leaving the pipes full of water and at rest for three or four months, or by substituting for the water, a weak solution of phosphate of soda in proportion of about a 25000th part."

The last conclusion, as will be shown in the sequel, has been abandoned by its author, actual experience having shown the positions, even under his own direction, untenable.

These conclusions have been confirmed, for the most part, by Taylor. (*On Poisons in Relation to Medical Jurisprudence and Medicine*, by Alfred S. Taylor, F. R. S. *Lect. on Mat. Méd. and Jurisp.*, *Guy's Hospit.*, edited by Dr. Griffith.) Taylor found that if the saline impurities are less than $\frac{1}{15000}$ part of the weight of the water, it is liable to attack lead, for the Thames water, which contains about $\frac{1}{1000}$ part, produced in nine years no carbonate of lead on 58 square inches of lead exposed to its action; the loss by evaporation during this period being kept up by fresh supplies of water. A similar counter experiment with distilled water formed carbonate of lead, but equal parts of distilled and Thames water wholly prevented action on lead. The waters of Edinburgh contain about $\frac{1}{17000}$ of salts, and act but little on lead. To what cause is this absence of action to be attributed? The opinion of Christison is, that it is due *chiefly to carbonates*. Taylor thinks, that *sulphate of lime* is the great agent in this preservative action, and that this is effected by its preventing the formation of carbonate of lead, $\frac{1}{1000}$ of sulphate of lime being sufficient for this purpose, and conferring on distilled water the power of no longer acting on lead. This was the opinion of Vauquelin forty years since. So also, Richard Phillips, Jr. (*Chem. Gazette*, Jan. 1845,) in his paper on this subject, attributes to sulphate of lime the power of preventing the formation of any compound of lead, soluble or insoluble in water.

The opinion, common not only to those chemists, whose experiments and results have been mentioned, but to a large portion of other persons, is, that by the action of neutral preventive salts, an impervious coat of oxide, or salts of lead is produced, which resists further action of water on metallic lead. The question

is so limited to the action of carbonates and sulphates, that Christison distinctly states, that salts in proportion, probably greater than a 4000th, will be insufficient to protect lead, "if they are in a great measure muriates;" and Taylor believes, that the presence of much saline matter, unless of the *right kind*, does not prevent the action of water on lead; while Phillips states, that muriate of soda, or common salt has none of the preservative power of sulphate of lime.

Tanquerel, as it may be rightly inferred, from what has been shown in the chapter on causes of lead colic, attributes to the water of Paris lead aqueducts, a preservative power, due to the formation of a coat of carbonate of lime which the water contains.

That this preventive action of neutral salts is impeded or destroyed, seems also a result of experiment. It is neutralized by galvanic action, caused by contact of some other metal with the lead, as the solder for uniting the joints of pipes. "It must never be forgotten, that carbonic acid, if present in the water, will completely counteract the preservative effect of the salts above mentioned." (*Guy Foren. Med.*, New York, edited by Dr. Lee.)

Prof. Daniell, of King's College, London, is decidedly of the opinion, from experiment, that all water dissolves lead if it contains an excess of carbonic acid. On the other hand, it is found that the presence of sulphate of lime, selenite, gypsum, or by whatsoever name it may be called, has not always prevented the action of water on lead. In the chapter on causes of lead paralysis, it will be remembered that Tanquerel quotes from Van Swieten, the case of a family who drew up the well water in a leaden bucket, and all were made sick with lead complaints, and this water contained a great quantity of selenite.

Prof. Horsford, of Cambridge, found four out of five "hard water" wells in that place did not contain lead after several hours standing in lead pipe, their saline ingredients being "mostly carbonate of lime," and the fifth well dissolved lead at the rate of $1\frac{1}{2}$ gr. in a gallon in thirty-six hours; differing from the others, in "the single distinguishing attribute, thus far ascertained," by "its possession of gypsum in solution in large quantity." (*Report of Consult. Phys.* Boston, 1848.)

In my experiments on the solvent power of Merrimack river water on lead, in 1835, I noticed a decided diminution of action

from day to day. All experimenters have noticed the same fact. That this corroding action of all natural water has ever ceased, in aqueducts transmitting water, which originally acted energetically on lead, is not proved by experience, though experiment, in the laboratory, may appear to warrant the contrary opinion. No well attested instances have been adduced, where neutral salts or other agents have had such a protecting effect on pipes in actual use. It has been shown how very cautions are the remarks of Christison on this subject, to prevent a practical inference being drawn from his experiments, sanctioning the idea, that the action ceases. "Unforeseen circumstances may," as is well observed by Christison, and admitted by Taylor, "counteract all preservative effects," and, even with the "precautions" prescribed, will ever continue to counteract this effect. In the conflict of opinion on this question, full as it is of the highest practical importance, and on whose correct determination the health and life of countless individuals depend, an appeal lies to the high court of daily experience.

The facts proving that water continues to act on lead as long as it is in contact with it, may be arranged under three heads, dependent on the varied effects produced.

1. The effects of well water.
2. The effects of spring water remote from habitations.
3. The effects of rain, pond, lake, or river water.

1st. Well water differs generally from other natural waters, by the abundance of nitrates which it contains. This fact has been noticed by Berzelius, in Europe. I have confirmed it in the water of a great number of wells in Lowell; its presence is almost universal. I have found nitrates in well water from some of the adjoining towns. A very competent chemist has, at my request, examined, and with a similar result, the water of several wells in an inland village on the banks of the Connecticut.

The amount of saline matter in all wells which have come under my observation, has exceeded the lowest limit assigned to the efficiency of protective influence. Yet, in all cases which I have examined, where lead pipe has been introduced into the well for the purpose of a conduit, the water has been found to contain lead, years after the pipe was first used; often serious lead maladies have followed the use of such water, after the pipe had been long in service; lastly, such pipes have been eroded deeply, in many instances perforated, and thereby rendered

useless. How far this erosive action is due to the presence of nitrates will hereafter be considered. In all cases an internal coat had been formed, lining the pipe with an incrustation of oxide, carbonate, sulphate, and chloride of lead, a compound of salts of lead, earths, and organic matter, which has so often been noticed, and thought to be a preventive coat. Underneath this covering pits were discovered, more or less numerous, contiguous, forming channels, or single and quite remote. The coat over these caverns was generally elevated, and mamillary protuberances were thus produced. As usual, in like cases of metallic erosion, the action had been most energetic beneath this elevated portion of the coat, the pits being generally bright, and of metallic appearance.

This action in distinct points, on a metallic surface, is common to metals corroded by water, or saline solutions; it occurs on the copper sheathing of vessels, and on iron exposed to moisture. This is a fact of the highest consequence, showing that a surface of great extent should be used in all experiments on the action of water on lead; pits are not unfrequently some feet apart, where the action is feeble, and often quite isolated where the action is more energetic. An observer examining a pipe in points not exhibiting pits, would infer there had been no action by the water.

Lead pipes, used in wells, in some cases have been perforated in six months. In one case, in Lowell, where a new well was sunk, in a district not previously crowded, or exposed to the drainage of the locality, the lead pipe conducting the water was so eroded at the end of three years as to become useless. New pipe was supplied, which also became useless at the end of about the same period of time, and the third set of pipe, now in use, requires frequent repair, having performed nearly the usual service of its predecessors. It is not uncommon for the erosion to go on within the pipe till the film of lead, forming the outer boundary of a pit, is too thin longer to sustain the atmospheric pressure. When the pump is first partially exhausted of air, the film gives way, bursting *inwardly*. The plumber, having mended one hole, produces another in the attempt to "catch the pump."

These facts are not peculiar to the well water of Lowell. Long ago, as Tanquerel has shown, Dr. Wall, of Worcester, in England, noticed a lead pipe destroyed in about three years by

water, at a farmhouse. Dr. A. A. Hayes confirms the facts by similar observations on lead pipes in the wells of Boston and its vicinity. In one instance under his observation, the portion of the pipe immersed was eroded so completely, that it separated from the main pipe and fell to the bottom of the well. In the letters subjoined, corrosion is proved by disease.

Similar facts of the continued erosive action of well water upon lead pipe are familiar to plumbers and pump-makers. They are too well and widely known to require confirmation. But if further evidence of the continued action of well water on lead pipe is required, it may be found in the letter of the Consulting Engineer of the Boston Water Works, to the Board of Water Commissioners. (*See Report of the Consult. Physicians of the City of Boston*, p. xxxvii., 1848.)

"From experience," says the Engineer, "I was able to detect the taste of lead where the water was used some three years, without any apparent injury to the family, who used the precaution of drawing off when it had been allowed to stand any considerable time in the pipe." These are very important facts; they show that there was continued action for at least three years. Lead, during this time, could be detected in the water "by the taste," and, as the engineer states, that he "had from experience known the ill effect of lead on water drawn from a well some 200 feet," it may be inferred that the "ill effect" was not confined to the water, but extended its action to the systems of those who used it. Hence the "precaution of drawing off." It is this "drawing off" which speaks better than experiment in the laboratory, that the action of water on lead is ever continued. It may be added, that the lead pipe in the "hard water" well, which Prof. Horsford reports, as above quoted, page 366, was removed after two or three years' use. The suspicion which had been already awakened of the deleterious quality of the water, was strengthened by the results of Prof. Horsford's analysis. He has kindly sent me a portion of the pipe, the erosions in which, notwithstanding a coating, are too deep to allow other conclusions than that they were the effects of many months' action.

The eminent scientific character of the gentlemen who have reported the last two cases of continued solution, gives the highest authority to the evidence of the fact of constant erosion. As individual cases, they are opposed to the doctrine of protective

influence. But the testimony of Mr. Jervis to this point seems to be of wider application.

“My observation has lead to the conclusion, that, with the precaution of running off the water that has stood through the night, or for any considerable time in the pipe, no practical effect of an injurious nature will be experienced from the use of lead.” (*Report of Consult. Physicians*, p. xxxvii.)

We trust we do no injustice in considering this language, as intended by its author to convey a general proposition. If it is not, if it is a particular proposition, drawn from this single observation, then is it not applicable generally. If it is a general proposition derived from wide and varied observation, then is the experience of the Consulting Engineer of the Boston water works wholly opposed to the result of the elaborate experiments of Prof. Horsford.

Indeed, this statement of Mr. Jervis admits all that an unbeliever in the safety of using lead pipe would claim, continued erosion and constant danger. It reduces safety to the precaution of “running off.” Hence, leaving to the imminent risk of disease all who disregard this precautionary measure.

The fact of continued erosion, is proved also by the lead diseases, which have occurred in one or more persons who used the well water flowing through the pipes. That diseases from this cause are very common, is demonstrable. Cases of severe lead colic, paralysis and neuralgic affections have been reported to me by several physicians residing in the country, and where the wells were not connected with the habitations of a crowded city. A part of these are subjoined, not only as valuable proofs of the continued action of water upon lead, deduced from the occurrence of disease, but as showing how insidious are the attacks of lead maladies.

And, perhaps, I may not better illustrate this part of the subject, both as relates to pipe and disease, than by presenting an extract from a report, drawn by myself, and alluded to in the subjoined letter of Dr. Dalton in these words: “The matter assumed so much importance that a memorial was addressed by the physicians to the City government, requesting that measures might be forthwith instituted for its thorough investigation. This memorial was favorably received, and a report embodying the results of chemical inquiry subsequently given to the public.”

EXTRACT FROM THE "REPORT OF THE JOINT SPECIAL COMMITTEE ON
THE SUBJECT OF THE EFFECTS OF LEAD PIPES UPON WELL WATER
IN THE CITY OF LOWELL."

1. The true answer to the first part of your letter is to be found in the knowledge of the action of water, and of salts, upon lead.

2. Lead, scraped bright, and exposed to air, or water, soon tarnishes. This tarnish is the rust or oxide of lead. It forms fast when lead is heated in air, and still faster on melted lead. This rust, or dross, or oxide of lead, is dissolved by pure water, by alkalies, as potash, soda, ammonia, by lime. It is readily dissolved by various acids, particularly by nitric and acetic acid, or aquafortis and vinegar, and by several vegetable acids. It rapidly forms in contact with fermenting matter, and is dissolved by the acid thus formed.

3. Pure water alone will dissolve the rust of lead. One pint dissolves a grain of lead. Hence, the purer the water, the greater the amount dissolved.

4. The action of pure water is modified by the presence of carbonic acid. No natural water is pure. All contains carbonic acid. If the carbonic acid alone existed in water, that would change the dissolved lead into white lead, which would thus be diffused through the water, in small and invisible particles, requiring long repose to settle.

5. The presence of salts, also modifies the action of pure water.

6. The salts in the natural water of Lowell, are common salt, copperas, alum, saltpetre, salts of lime, such as sulphate of lime or plaster of Paris, muriate of lime, and nitrate of lime, or saltpetre lime. It is a variety of saltpetre having the same acid as that, but its potash replaced by lime. There are also small quantities of salts of magnesia, and of ammonia. The most abundant salts, are copperas, alum, the varieties of saltpetre, and common salt.

7. If the salts only modified the action of water upon lead, or if one salt alone existed, which soon of itself acted as a protector, which is the current opinion, then the presence of a salt would be a positive benefit; for 2000 parts of plaster of Paris would prevent the action of water. The salts themselves exist

not single in water, but mingled. They act on each other, giving rise to products which act on, and dissolve lead. In some classes they act themselves on lead, and the substance so produced is dissolved by well water.

8. The action of salts contained in Lowell water, though somewhat complicated, is easily understood. The most active among the salts, are those which have been said (section 6) to be most abundant. These are copperas, common salt, and the variety of saltpetre called lime saltpetre. To understand how these act, let their composition be briefly stated.

1st. Copperas. It is composed of oil of vitriol and of iron. Exposure to air rusts the iron, and a portion of the acid becomes free.

2d. The lime saltpetre is composed of lime and of aquafortis. The other varieties, of potash, or ammonia, or soda and aquafortis. The effect of mingling the free acid of the copperas with these would be to set free their aquafortis, which would then immediately dissolve the lead. Copperas alone would act on the lime saltpetre, but in this case no free aquafortis is formed. The compound of iron and aquafortis, now formed, is liable still to act on lead.

3d. Common salt is composed of soda, and chlorine; muriate of lime, of lime, and chlorine. The effect of free acid of copperas is, to let loose the chlorine, or to form muriatic acid. This acts to dissolve lead.

9. The action of common salt, or muriate of lime, does not depend upon free acid of copperas. Lead decomposes common salt. It unites with its chlorine, and thus forms chloride or muriate of lead, which, if heated, would be King's, or patent yellow. This compound, thus formed, as also that produced by the action of free muriatic acid, is easily soluble to a small extent in water, more soluble in acid water, and quite soluble in alkali. When lead then decomposes common salt, the soda, if no free acid is present, renders this compound more soluble.

10. From the variety of salts present in water, the soda, produced as above (9), is usually converted into sulphate of soda; or, if muriate of lime is decomposed by lead, there is also usually formed, in like manner, sulphate of lime. If free nitric acid, formed as stated, (8, 2d,) is present, we have only formed the varieties of saltpetre.

11. When lead is dissolved in salt and water, the process con-

tinues till the salt is all used. After some time standing, the lead is re-deposited in little distant white knobs and threads, varying from the size of a pin's head to that of a pea. If these are removed, the lead is found to be pitted, and very bright in these places.

12. The facts to be chiefly remembered in 9, 10, 11, are, that common salt corrodes lead; that the substance so formed is soluble in water; that it is still more soluble in nitric acid, whose presence in water has been shown possible, and in free vegetable acid.

13. That a large amount of such acid exists in Lowell waters has been found by repeated analysis. This acid exists also in the rivers which flow through the city, and it rapidly corrodes, and dissolves not only lead itself, but also particularly the white substance produced by common salt and lead.

14. All alkalies, as potash, and soda, and lime, dissolve the compound of lead and salt. They decompose and dissolve the compounds of lead and oil of vitriol, or that formed by the action of copperas.

15. Were the salts of limited amount, it is evident that they would soon, in contact with lead, destroy their own action. But their supply is as unlimited as that of the water. Their origin may be here referred to. Those only, whose effects on lead are greatest, need here be regarded.

1st. Copperas. It arises from the natural decay of iron pyrites, or a compound of sulphur and iron.

2d. Saltpetre is well known to be constantly formed on the surface of the earth, wherever animals or vegetables decay. These form the acid, and the soil affords the lime and alkali. I have, in no one instance, and my analyses have been extensive, found nitrates, or the various forms of saltpetre, absent from the well water of Lowell. I have detected nitrates in several small streams in the neighborhood of this city, and once in the Merimac. Probably nitrates will be found always in it during a freshet.

3d. Common salt. It comes down with every rain. I find this to have been the case in every fall since March last. It is probably a universal ingredient in rain water. Salts of lime, as muriate, perhaps sulphate, and of ammonia, also accompany rain. It is evident, then, that the supply of salts is as exhaustless as the rain itself. Small in quantity, to be sure, yet bounti-

fully and beneficently supplied for natural operations, especially vegetation, and injurious only when man subjects his contrivances to those laws which regulate the action of salts on other matter.

16. The great and efficient cause of the action of these on lead, will be found in the natural decomposition of copperas, whose free acid then acts on the nitrates and muriates of lime.

The next most powerful corroder is common salt. The vegetable acid acts least in ordinary cases; though, occasionally, I have found it so abundant in the Merrimac river, as to dissolve in twenty-four hours as much lead as would pure water.

This explanation of the cause of the corrosion of lead, will be seen at once, by those conversant with the usual chemical books of the day, is counter to the current opinion. It would be offered with greater diffidence were it not supported by two facts.

1st. Leaden pipes are extensively corroded, and in some cases rendered thereby useless, in the well water of Lowell. This fact is well known to many of our citizens. It is not confined to particular portions of the city, and occurs even in hard waters.

2d. Analysis detects lead in the water of Lowell wells, into which lead pipe is introduced. The analyses of the water of a great many wells, in different sections of the city, in no one of which has lead been absent, authorizes the conclusion, *that lead is dissolved by all well water of the city.*

17. Lead may exist also in suspension in water (4). If the action of salts is, as has been supposed, to form a protecting coat over the lead, then, the tremulous motion communicated throughout the pipe by the act of pumping and other causes, would detach this first formed coat. It may be added, that lead, in such invisibly diffused particles, has been thought by many, to be the only form in which it is usually found in water, flowing through lead pipes.

18. Whether lead exists in water, suspended or dissolved, is of little moment. The fact that it does exist is of the highest interest. Nor is it of essential consequence to state the quantity per gallon which may be found. The quantity varies, dependent on two causes.

1st. Proximity to sources of nitrates and muriates.

2d. The geological character of the underlaying, and surrounding rock.

19. The sources of nitrates, are stables, styes, and vaults. It is not to be concealed, but deeply lamented, that the abomination of desolation standeth too often where it ought not. There is good reason for the opinion, that the common receptacle for the water which has been drank, is too near the source from which it was drawn, not to have affected its quality. In the wonderful laboratory of a vault, beautiful changes are going on which excite our admiration. The products of these transformations are harmless in themselves. They no longer remind one of their origin. Acting on metals, in obedience to laws, which were impressed on them at creation, we cannot doubt but that the greater their production, the greater the chance that leaden pipes will there be most acted upon.

20. The geological character of particular districts of the city, affects the quantity of lead dissolved by the well water. For popular use, Lowell may be naturally divided into three geological districts; each distinct, and which may be termed, 1st, the copperas; 2d, the gravel; and 3d, the clay district.

1st. Lowell reposes chiefly on slate rocks, of those varieties called mica, and talcose, or clay slate. The high ridge called Chapel Hill, extending from Concord river to the railroad, and the ridge extending from the railroad gap to the foot of Appleton street, are composed of mica and talcose slates, highly charged with sulphur and iron. This forms copperas (8). The water obtained from this ledge is charged with copperas. There are, however, many places in this district, where the water is merely top water, which filters through the bed of covering gravel, down to the ledge, without entering it, and it is as free from iron as that obtained elsewhere.

2d. The remainder of Lowell proper, reposes on a more compact variety of slate, passing into clay slate, much less charged with sulphur and iron, and covered generally many feet in depth, with sand and gravel. The water in this gravel district is chiefly top water, which filters through the gravel, down to the rock; but even in the gravel region, veins of water are occasionally met, charged with the like salts, which are formed in that of the copperas district.

3d. That portion of the city called Belvidere, reposes on clay, which again is underlaid by a rock, called gneiss. The clay is covered with a fine white, clayey gravel. The water of this clay district contains less copperas than that of the others.

21. Referring to these natural geological districts, and to the proximity to sources of nitrates and muriates, it is evident, that particular situations, and on these, particular spots will be found where lead will be much more corroded than on others. Hence, it is found by analysis, that some well water is so highly charged with lead, as to be detected in a few minutes by the simplest tests, while others require an elaborate analysis and delicate tact, to enable one to perceive that in them lead exists. No case has come under my observation, in which lead has been absent. It may be stated, as a general inference, that lead in water will be in proportion to the copperas, and muriate and nitrate of lime. If the copperas was entirely withdrawn, the action of the muriates of lime and soda would be the next most active cause of the erosion of lead. The action of these last is much promoted by vegetable matter in fermentation, or the natural decay of wood. Lead is sometimes corroded only where in contact with decaying wood.

The next subject, in the order we have proposed, is the action of spring water situated far from inhabited districts. Spring water is in New England, at least in its primitive region, generally pure, that is, not so highly charged with neutral salts as well water.

With the exception of nitrates, the kind of salts is similar to that of wells. In fact, springs are the gushings of natural wells. Hence we may expect from this action of spring water, results similar to those produced by well water, but in a much less degree. The following observations, may be adduced as proofs of its continued action. The character of the salts of the spring water in the vicinity of Boston, does not allow the inference that they are highly protective according to the scale of Christison and others. I have seen lead pipe which conveyed spring water, at Jamaica plain, Roxbury, which was very much eroded and slightly perforated by the enlargement of an original defect in a part of the pipe. The water was very pure, and yet, notwithstanding a deposited coat of oxide and carbonate of lead had occurred, the erosion continued, and lead was dissolved at the end of eight years' use of the pipe. This was conclusively and positively determined, by finding lead in solution in the water, by analysis, before inspecting the pipe; and without the aid of analysis or inspection, the fact of continued corrosion might

have been inferred from the abdominal pain, amounting to colic, and many other symptoms of unmistakable lead disorder which occurred in one person, whenever he drank this water.

A distinguished scholar and eminent divine, residing at Dedham, Mass., was for years tortured with a complication of the worst forms of lead disease, before its cause was discovered. It was found in the use of spring water, transmitted about half a mile, through lead pipe. The continued action of water on lead was conclusively shown by the fact, that the disease with which this person was suffering, compelled him, in 1838, to retire from his labors, and seek a restoration to health by journeying hither and thither. He returned well, and the cause of his ailments being still unsuspected, the use of the water was resumed, when in 1840 the attack of lead disease was so severe, as to lead to the belief, that it would terminate life by paralysis of the intercostal muscles. The water was now first examined, and found to contain lead. It was abandoned, and the long train of neuralgic, paralytic, and arthralgic symptoms, peculiar to the action of lead on the system, gradually disappeared. It may be added, that during the many years of this case, other sources of water were mingled with that of the original fountain. This will not affect the proof of the continued action of water on lead, afforded by this well defined case, though, during a portion of the ten years' suffering, the character of the water derived in part from other sources, was allied to that from ponds.

The State Lunatic Hospital at Worcester, Mass., was supplied for many years with spring water transmitted over a mile, through lead pipe. It was laid down in 1833. Ten years after this a case of disease of anomalous character was noticed, which Dr. Woodward attributed to lead introduced from some source into the system. The water used at the hospital was suspected, and being forwarded to myself for examination, was found to contain lead. An iron pipe has since been introduced.

✓ The case at Tunbridge in England is full of instruction, not only on the fact of continued action of water on lead, but it demonstrates also, how small a quantity of lead will produce serious disorder. This water was analyzed, by the celebrated chemist Dr. Thomas Thomson, who found it remarkably pure, containing $\frac{1}{1000}$ of saline matter, three fourths of which were chloride of sodium or common salt. In 1814 a pipe of lead was laid to conduct this water about one quarter of a mile to Tun-

bridge, for the use of those who chose to take it. In about a *year after* the water was used, a great many cases of colic, and one at least of paralysis, evidently lead diseases, appeared. The water was examined, and lead discovered in it by Prof. Brande, of the Royal Institution. Iron was then substituted for the lead pipe. Lead maladies disappeared.

The quantity of lead was almost inappreciable, and escaped the acute analytical tact of some of the best chemists of that day; a fact which Christison thinks may be due to the carbonic acid of the air having precipitated the dissolved hydrated oxide of lead, by exposure of the water submitted to experiment. The whole case is a lesson that chemists should be cautious in deciding that a cause of a disease did not exist in the use of water from a lead pipe, when experience shows, that the supposed cause being removed, the effect ceased.

Remarking on the purity of the Tunbridge water, Christison observes, "no such water can be safely conveyed in new lead pipes." It is believed that had the lesson which time has taught him, been earlier acquired, Christison would not have limited safety to *new pipes* only. ✓ He reports the following cases, and as will be seen, with that love of truth which ever distinguishes the genuine disciple of science, confesses that his theoretical views, based on laboratory research, have not been found practically true. These cases are quoted, not less to prove the continued action of water on lead, than to show, that this action occurs where there was the highest probability of natural and artificial protection.

1. A house of a gentleman in Dumfriesshire, where Prof. Christison was visiting, was about to be supplied with water from a spring about three fourths of a mile distant. Christison finding no action on fresh cut lead, placed in a tumbler of this water for fourteen days, advised the use of lead pipe. When the water was finally thus transmitted to the house, soon after being drawn into vessels, it became of a hazy, white appearance, and the glass vessels became incrustated with a pearly white film. A cistern into which the water was drawn, became as white inside as if painted. This water was unusually pure. Its solid contents about $\frac{1}{22000}$, sulphates, muriates and carbonates. The tumbler experiment, Christison remarks, is not a correct representative of what is to go on in the pipes, where the water flowing through 4000 feet of $\frac{3}{4}$ inch pipe passes over a surface of 784 square feet.

2. Another house in Banfshire, was supplied with water from a spring three fourths of a mile distant, through lead pipe. Two years and a half after this, the owner of the house was seized with severe abdominal complaints, which did not yield to any treatment. He left home, went to Edinburgh, and there gradually recovered. Returning home, the use of the lead aqueduct water was resumed, when the disease which before afflicted him returned. Two others of the family were similarly, but not so severely attacked. Happening to see, in Chambers' Journal, some account of the case above, the afflicted gentleman then noticed the white film in his chamber water bottle. The water was now analyzed, and lead detected in it. Dr. Christison found the solid contents of this spring water to be $18\frac{1}{2}\text{gr}$, principally muriate of soda, sulphate of magnesia and lime, with only a very little carbonate.

This, therefore, says Dr. Christison, was exactly a case where action was to be anticipated, as the principal portion of the salt was very feebly protective.

3. Lord Aberdeen's country residence was supplied with water through lead pipes, from a spring, which was said to be very pure water. The housekeeper and her niece were constant residents at the house, and after eight months' use of this water, were both taken sick, — the housekeeper with symptoms of violent, unyielding lead colic, which was not recognised as such till the surgeon saw the white film on the water bottle; he then recollected the Dumfriesshire case, treated his patient for lead colic, and she was cured.

On analysis, this spring water gave $11\frac{1}{2}\text{gr}$ of solid matter, which was nearly entirely chloride of sodium, with a little chloride of magnesia and lime, and no carbonates. The sulphates were only $32\frac{1}{2}\text{gr}$. This analysis was performed by Dr. Christison who remarks, it is plain what ought to have taken place, and continuing his observations, he states "that where action is observed in particular waters, in some cases it may be impossible to prevent it by any attainable means." "A remedy may be found in unusually pure spring water, by leaving the pipes full of the water for a few months without drawing off, or perhaps even more effectually by filling the pipes with a solution of $35\frac{1}{2}\text{gr}$ of its weight of phosphate of soda. I had determined, (says Dr. C.) to try this last in the Dumfriesshire case, but first tried the plan of shutting up the pipes full of water. This was

done for three or four months. The water after this passed with scarcely any impregnation of lead; what little was contracted gradually disappeared. Probably, (continues Dr. C.) neither method will be more than of temporary use, when the chief or only salt present is chloride of sodium, even though the proportion be considerable. Both plans seemed to answer for a time in the instance at Lord Aberdeen's, but after a while, the action recommenced, probably owing to the deposited carbonate(?) being redissolved." At the time this case was published in the Transactions of the Royal Society of Edinburgh, the cure appeared perfect and was there reported to be so. In the fourth edition of his treatise on Poisons, Dr. Christison makes the above correction.

Dr. Adams, of Waltham, reports a case of lead disease, from use of spring water, where the pipe had been in use six or seven years. (See his subjoined letter.)

The last class of facts proving the continued action of water is derived from the observed effects of rain, river, lake, and pond water, on lead. That rain water, being a natural distilled water, would have a rapid action on lead, might be inferred from its purity. That it has this action, erosive, as well as solvent, is abundantly evident from the instances quoted in the body of this work. That this action is not suspended by the formation of a protective coat, is attested by the many years during which ill effects have been induced by the use of rain water thus lead charged, the severe cases of colic which Tronchin and others record as occurring among the inhabitants of Amsterdam and Haarlem, as long as they collected rain water from leaded roofs, and conducted it by lead gutters to lead lined cisterns. That a protective action is not afforded by the salts contained in rain water, depends on the fact of their quality and presence in too small a quantity to come within the assigned protective limits, as the advocates of this doctrine may affirm; and that the compound of lead oxide and carbonate of lead, which is so readily formed on lead by rain water, does not act as a permanent protector, is proved by the facts above referred to by Tanquerel. Now, what is the water of rivers, lakes, ponds? Rain water, in which the quantity of salts, both organic and inorganic, is increased by the solution of mineral and vegetable matter, as it percolated through the earth, or remained in the natural reservoirs in which it is collected. Lake, pond, and river water, will

partake of the geological character of the country in which they are found; they differ from the spring water of the various geological districts, both in quantity and quality of their salts, the last being very much modified by the presence of organic matter. Hence, in limestone districts, lead pipes, transmitting the natural water of the locality, will have a thicker deposited coat than that found in pipes of lead aqueducts in districts of a different geological character. Yet, while all due allowance is made for these modifying circumstances, in preventing those deep erosions and perforations, which are observed in well water, and sometimes in spring water where carbonate of lime is not abundant; experience shows that the lead is dissolved, and may be, and has been, repeatedly detected by chemical analysis, years after the pipe had been in service. The solvent power of the water has been evinced also by lead diseases, produced by its use.

All river and lake water, shows, by experiment, an incipient action on lead; the water is found impregnated with the metal. This action diminishes, but never wholly ceases in actual practice. For,

1. The water of Merrimac river, flowing through a country emphatically granitic, I find holds lead in solution when drawn through a lead pipe which has been in use for its transmission eight years, the water having stood in it some hours.

2. The water of Jamaica Pond, drawn from the leaden pipes in Boston, which had been in use several years as service pipes, I found, in 1844, contained lead in two instances brought to my notice.

Dr. A. A. Hayes has detected lead in the water of Jamaica Pond, drawn from the lead pipes in Boston, supplying it for domestic use in such numerous instances, and under circumstances so various, that it is impossible longer to doubt the continued erosive action of that pond water on lead pipe in actual aqueduct use. (See his letter subjoined to this paper.)

3. Croton water, drawn from lead service pipe, which had been in use from the date of the introduction of that water into the city of New York, was found in my analysis in 1846, to contain lead in solution.

Dr. James R. Chilton, a distinguished and acute analytical chemist of New York, has also repeatedly detected lead in Croton water, drawn from lead pipes in that city.

These pipes, had, in some instances, been in use for many

months, even a year. (For the particulars of his observation, the reader is referred to his letter to the writer, which is subjoined to this article.)

4. Croton pipes, removed at the end of several months, are found to be much eroded in many cases. Those which had been lined with tin were found to have that coating removed in many points, and the lead there pitted. How long this action of erosion had been occurring, can be conjectured only, but as there was no evidence of its cessation, so neither is it to be inferred, that such deep corrosion could have occurred in the first few days after the pipe was used to transmit water.

The evidence of continued action of Croton water on lead, derived from chemical analysis, is supported by the fact, that at least one member of the family using water from the source whence was drawn that analyzed by myself, was affected with lead malady.

In this case, the evidence of the existence of lead paralysis and arthralgy, with many other symptoms so well described by Tanquerel, is undoubted. On ceasing to use Croton water drawn from lead pipes, the symptoms of lead malady disappeared. They were renewed when the patient, residing in the summer in the country, drank rain water, which had been transmitted through lead. Thus showing it was not Croton water, but the lead it had dissolved, which was the cause of disease. (See the letter to Dr. Nichols, appended to this article.)

Besides, this is not an isolated case; Dr. Chilton states that several persons had been made seriously ill from drinking Croton water from lead pipes in a house in New York, (which had been closed for some time previous,) and that he had detected lead in it. (*Rep. of Consult. Phys. of Boston*, 1848.)

5. I have examined small sections of lead pipes, which had been in use transmitting the water of James river, at Richmond, Va., about twelve years. There was a fine reddish colored, and quite smooth and compact coat deposited on the inner surface of the pipe, which was easily detached, showing evident and unmistakable marks of erosion, by small pits and thread-like channels.

Pipe from Baltimore showed a less compact coat, but quite as evident marks of the action of water, which had occurred in this pipe for several years in use.

Now the action here was in both cases slight; but this is evi-

dence, that so slight an action could not have been sufficient to produce the erosion in a few days. It may be inferred to have gone on for years; in truth, there is no evidence of the cessation of action. There must have been a period, when the water was first transmitted, during which action was more vigorous than subsequently. If disease did not indicate action then, so neither will its non-occurrence, during after periods, authorize the conclusion that action had ceased.

The facts above stated abundantly prove that lead pipe in actual use transmitting natural water, whether rain, spring, well, lake, pond, or river, is eroded or dissolved by that water, as long as the pipe is used.

This proposition is true as a general statement of fact. The probable cases and causes of exception have been pointed out, but even in these, experience is often at variance with the doctrine of the protective power of neutral salts. If there are frequent exceptions, then, to the rule of protection, where the quality of the water seems to authorize the hope of such action, it may reasonably be concluded that, in opposite cases, there is no probability that such a possible action will take place. Where there exists no probability of protection, there is the certainty of action. Experience has yet to prove, whether any precautions can permanently avert this action of water on lead. Certain it is, that nature has not provided the means of prevention in the case of lakes situated in primitive regions. On this question I would offer the following letter, written by the request of that eminent surgeon, Professor John C. Warren, M. D., of Boston, which, with the exception of the introductory paragraphs, has already been communicated by him to, and published in, the Boston Daily Atlas of March 11.

In re-publishing the letter entire, as a part of this article, the reader will pardon that which may seem repetitious; perhaps the importance of the subject will admit of some repetition, and that must be my apology. I do not feel it necessary to apologize for introducing here my opinion on a vexed question. I gave it only when it was requested. It was based on general grounds; as such, it is applicable here.

Lowell, February 10, 1848.

DEAR SIR,

You have asked my opinion on the use of lead pipes for distributing Cochituate water. I have made no direct trials of the action of that water on lead. My remarks must be based on facts generally admitted. Fortunately, the published Reports of the Boston Water Commissioners shed light enough on this point to guard one from error, in applying general inferences to this particular case. Though the experiments, there detailed, are not as full as is desirable, yet I doubt not more extended and varied trials, especially if made under circumstances more allied to the actual position of a distributing pipe, will show, that the slight effects noticed in the Report of 1846, will be found to be increased.

When bright metallic lead is exposed to the action of the common air, or free oxygen contained in river or lake water, its surface is soon tarnished, and a film of a gray color covers it. This film is the oxide or rust of lead. Lead rusts then, or oxidates, as would iron, in water.

The gray rust or oxide is dissolved by pure or distilled water. This is a fact which may not be set aside. All experiments have proved, that with the access of air, lead oxide is dissolved by pure water. The question whether *metallic* lead is soluble in water, has no bearing on the present inquiry, however it may be decided. Nor is it of any consequence whether the oxide of lead is in actual solution, or only mechanically suspended in water, so long as it is impossible to separate by the finest filters that which is too finely divided ever to subside, or to be distinguished from a true solution.

As in numberless, perhaps all cases of chemical combination, union is most effective at the instant of production, so here, the oxide of lead in the act of passing from the metallic to the oxide state, is most easily dissolved by pure water. It is the lowest or sub-oxide which dissolves. Pure or distilled water dissolves that at the rate of one grain per pint, or one oz. Troy in sixty gallons.

It is a just inference, then, that the nearer water approaches purity, the greater the certainty that it will dissolve oxide of lead. Water pure as distilled, provided it contains common air, as all natural water does, flowing through a lead pipe, will therefore gradually corrode and dissolve that. It may not be doubted, that when air and pure water are conjoined, lead water is formed as certainly and as easily as would be lime water, were that earth present. But water thus pure is not a natural product. It is enough for our purpose to have shown, that were lake water equally pure, there is no ground for an opinion that it will not dissolve lead.

There is, however, an opinion abroad that the impurity of natural

counteracts the solvent effects of pure water. It is further believed, that the mingled impurities, or foreign matters in water, mutually protect their action on lead. Their combined presence, it is said, destroys individual action. This opinion has been and is a source of erroneous views on the safety of using lead as a conduit or reservoir for water. It claims, then, our attention at the outset of this inquiry.

All natural water contains certain earthy and alkaline matters and acids, or combinations of these, called salts. These all may be divided into two classes — salts and acids. Let us call these salts by their usual name. They are common salt, Glauber's salt, Epsom salt, sal-ammoniac, varieties of saltpetre, copperas, alum, and plaster of Paris, besides others having no English name, but allied to the bittern of salt works, and the earthy part of bones. To these we may add chalk and magnesia.

The acids found in lake or river water, called organic, are derived from the decay of bodies once organized, whether animal or vegetable. Their chief source is in decaying vegetables. Among these, carbonic acid is an abundant product. This subject may be illustrated by referring the organic acid to vinegar or acetic acid.

As this is the product of fermentation and decay, so the various acids in water arise from like causes. It has been observed even that formic acid, so nearly allied to acetic, is sometimes produced by the decay of lignite or wood coal. Arrange now anew the elements of formic acid, part with some and add others, and chloroform is produced. So the continued new arrangements of the vegetable elements give rise to a variety of acids, or colored substances, soluble in and coloring water, or solid and extract like and insoluble in water.

There is no evidence that any of these organic acids are very stable compounds in natural water. Change of temperature, difference of exposure, contact with other bodies, keep their particles in change. We are not authorized to infer that the vegetable acids found in natural water have arrived at a stable state, much less to believe that they passed at once into that form in which analysis detects them. All analogy leads to the inference that numerous bodies, intermediate between wood and the various elements found in water, are produced during decay. These act on lead in a manner which no experiment can imitate. Here, again, if we refer to the general principles of chemical change, a body exposed to the influence of these changing acids, or vegetable elements, is more susceptible of being itself acted on, than if it were in pure water. Hence it has been found that lead was acted on only where in contact with decaying wood. The action of acids may be referred solely to the vegetable, for the existence of

free mineral acids is very questionable in lake water. These organic acids all dissolve the oxide of lead. It must be in that state before it can be dissolved by an acid. We may then here consider the action of the two great classes into which we have divided the impurities of water — the acids and the salts. And first, of the acids.

The lead being oxidated by the air contained in water, as long as that flows, the oxidating cause continues. The acids next act. Among these, carbonic acid holds a high rank. Next to this, are the vegetable extracts and soluble acids, which may exist in water seemingly neutral, yet the oxide of lead unites with these, and forms salts, which, not being easily soluble, precipitate on the lead or other bodies. Now, in a small experiment, the colored water becomes colorless, the lead perhaps actually gains weight. Yet the transparent water actually contains lead in solution. Purification *by lead* has operated as *distillation*. It may be remarked here, in proof of these facts, that *dark* colored rose water is sometimes rendered colorless by slips of lead immersed in it. The rose water of our shops is found also occasionally to contain lead, arising from this cause, or the use of a leaden worm in its preparation. The early laws of Massachusetts bear testimony to the solubility of lead in New England rum, an action due to its pure water, arising during distillation.

These compounds of lead and carbonic and organic acids are in their neutral state quite insoluble in water. It is well to bear in mind that few, perhaps no substances are to be called *insoluble*, where they are, in proportion to the water, in quantity infinitely small. Much less can a salt of lead and vegetable acid be said to be insoluble, when the acid of the salt exists in quantity, relatively to the salt, infinitely large. This is the condition of the salts formed in a conduit of lead, when the water is daily flowing through it. It is a well established chemical law, that all salts, with an acid excess, are more soluble than neutral compounds.

We are not authorized to infer, nor will the fact so be found, that any salt of lead with an organic acid, formed in a leaden vessel, is insoluble in lake water continually flowing through it.

It is well known that lead, immersed in lake water, soon becomes coated more or less with a white powder, which soon forms a layer on the bottom of the vessel wherein the experiment is made. This is white lead, produced by the carbonic acid of the water, which has combined with the film of oxide, solved by the water, and which has passed to a higher degree of oxidation. Even this white carbonated oxide of lead is soluble in water, though not readily, unless free carbonic acid is present. Similar difficulty but colored compounds are formed with the organic acids. Some of these, however, as the acetic

and formic, whose production in water has been shown to be not impossible, produce with lead perfectly soluble and colorless compounds. These acids not only dissolve the oxide as formed, but they will also decompose the carbonate and other insoluble salts, which have been mentioned. These may be re-decomposed by carbonic acid. In this fight of acids for the same base, that will be left as an impalpable powder, so minutely divided, that it will be hard to say whether solution, or minute mechanical division, is the worst form in which lead can exist in potable water.

It is evident, therefore, that organic acids cannot be relied on as protectors against the action of lake water on *lead*. So far as these exist, they render that a better solvent than is distilled water.

And now, let attention be turned to the salts. The number of these and their quantity is far less in lake and river water, than in that of wells in districts inhabited. The action of this last is more energetic and complex. But some of the causes, which have, in all wells, acted on lead pipe, do exist in lake water. Among these are found the compounds of chlorine with alkalies and alkaline earths and iron. These form a class of salts termed formerly *muriates*, but now *chlorides*, by which name they will here be called. Among them are :

Common salt, or muriate of soda — or chloride of sodium.

"	"	potash,	"	potassium
"	"	magnesia,	"	magnesium.
"	"	lime,	"	calcium.

The chlorides differ from other classes of salts in water, by this — they are compounds of chlorine and metals in their metallic state. The metal, before it may combine with chlorine, does not require to be oxidated. Supposing a compound of lead and chlorine to be about forming, no common air or free oxygen is necessary, as is the case when vegetable or other acids form their salts. Chlorides would form in lake or other water, were all its common air and free oxygen withdrawn. The action of salts in lake or river water may be referred chiefly to *chlorides*. These act so efficiently, that other salts have only a partial effect. The chlorides act primarily. The other mineral acid salts act never primarily on lead.

Among the long known and best established facts of chemistry is this, that lead in a solution of an alkaline chloride is corroded. Later observation has extended this fact to the perchloride of iron. This is of the highest importance in considering the use of lead pipe. In all these cases, the chlorine passes from the salt or the muriate to the lead, and a muriate or soluble chloride of lead is formed.

The alkali previously combined with the chloride becomes free, and

is immediately seized by the uncombined organic acids. Compounds with these result, whose presence ultimately tends to render salts of lead, usually ranked as insoluble, quite easily and abundantly soluble in water.

It is only within a few years that it has been well ascertained, that compounds of ammonia, with organic acids, dissolve sulphate of lead, heretofore considered so very insoluble; and the remark may be extended to chloride or muriate, carbonate and acetate of ammonia, not uncommon salts in lake water, though easily lost in its analysis. So acetate of soda easily dissolves sulphate of lead; and even while I am writing, the superintendent of our color shop has brought me a new product, formed in one of his processes, which is carbonate and acetate of lead crystallized together. Now sulphate of lead, which thus appears so readily soluble, will result from the action of sulphate of soda, the Glauber's salt of lake water, on the soluble chloride of lead, formed as above described, or on the salts of lead formed by organic acids as has been before shown.

So, too, in further illustration of the increased solubility of a salt, plaster of Paris, or sulphate of lime, is much more soluble in common salt and water, than in water only. So also chloride of lead, formed as we have seen it is, and soluble in water, is dissolved in much greater quantity when organic acids or their acid salts are present.

And here, in connection with this subject of difficultly soluble, being solved by other easily soluble salts, it may be mentioned that phosphate of lead, so much relied on as a protector of lead pipes, is readily dissolved by the feeblest acids.

Phosphates exist in rain water, and though not abundant in that of lakes, the fact that they are so readily dissolved, should guard against relying on their protecting power. The organic acids of lake water will solve them, and analogy leads to the belief that, like the bone earth in agriculture, even so weak an acid as the carbonate of percolating rain will be found to dissolve phosphate of lead.

That compounds of lead and chlorine result from the action of the chlorides of lake water, is the first great fact, which fixes the attention when turned to this subject. That this compound is readily solved by the water, its acid and salts, may not be disputed. It is dissolved in water, where other salts of lead, and other earthy salts and organic acids co-exist. If proof were wanting, reference may be made to the wells of Southampton, England, which rapidly destroyed lead pipes. They were converted into chloride of lead by *free* chlorine in this case. That will not effect the result. The chloride of lead existed in conjunction with other salts of that metal; the chloride being 1.16 grs. and the carbonate of lead .29 gr. of oxide per pint. A great quantity of

chloride of sodium, lime and magnesia, sulphate of lime and vegetable matter, co-existed in this water, with the above large amount of salts of lead.

That this compound of lead and chlorine will be decomposed by some of the salts of lake water and sulphate of lead, heretofore considered insoluble, result and be rendered abundantly soluble, will not be denied. Nor will it be denied that the chance of any salts acting as protectors is exceedingly small. It is a result not to be hoped for, by one who duly considers the mutual action of salts in solution. The doctrine of incompatible salts in natural water is now much restricted. The mode in which salts exist in solution in water is a problem which chemistry has yet to solve.

Such are the results to which chemistry would conduct us without direct experiment. Whatever has been, or may be, the results of such experiments, they should not shake our faith in the conclusions at which we have arrived. All experiments on this subject want the essential elements of time, quantity, electrical condition, a constant flowing stream from the original fountain, and varying temperature and pressure. The effects of this last have been proved both by our own countryman, Prof. Mapes of New York, and by Col. Yorke of England.

If direct experiments should not fully confirm the course of reasoning which has been offered, it will be because the circumstances in which they have been performed differ widely from those to which a lead pipe is exposed in distributing water from an iron main.

Happily, we are not left to the light of doubtful experiment to guide us to correct conclusions. There are great operations of nature going forward, which teach how lake water acts on lead. This teaching is corroborated by the chemical analysis of water, supplied from natural sources through canals of masonry and iron mains, and distributed through leaden pipes, fortified perhaps by tin, as for instance, Croton water in New York city. Should chemical analysis detect lead in this water, thus distributed, if its use has produced disease, whose character indicates lead as its cause, and if abandoning the use of such water leads to the restoration of health, we shall have the conclusions of chemistry confirmed, by evidence which is perfectly satisfactory.

A test of correct reasoning on this subject may be found in the results of the examination of the action of rain water on lead, where that has been exposed to its influence in the open air. Let us then begin with this product of a great natural distillation, rain water. Let it be inquired of this, how far the presence of salts affects its action on lead.

Long continued observation and analysis has assured me that nearly all the salts of the ocean are found in rain water. Chlorides are always present. Nitrates often, ammoniacal salts and organic acids generally.

The amount of these varied salts, with the organic acids of lake, present in rain water, is per gallon 1.603 grains. One inch of rain will afford 6.268 lbs. per acre, or one inch of rain is equal to about one grain of salts per square foot. This will give at the rate of 30 inches annual fall on the district included in the 12,077 acres of Lake Cochituate and its drainage land, 2,270,959 lbs. of salts..

I have a record on August 9, 1845, of the action of rain water on lead. A sheet was unrolled and laid on a platform out of doors. A slight sprinkling of rain occurred. The drops ran together in irregular patches on the lead, but in pleasing and grotesque shapes. Where this happened, the lead was *etched*, the figures, as the water evaporated, being left bright. Where the water stood in the little depressions of the unrolled but not smoothed sheet, there too the lead was bright. The water in these little pools was collected, carefully filtered through paper and tested for lead. It was found abundantly. I have ever regretted that I did not take an impression from this natural etching, which was quite deep enough for picture printing.

Similar facts are well known to those conversant with erecting leaden chambers for the manufacture of sulphuric acid.

So, too, diseases caused by using water collected from leaden roofs and gutters, have given sad proofs of its powerful solvent action on that metal. We may here refer to the substitution in Amsterdam of lead for the tiles, which were previously used. It will be remembered, by those familiar with the work of Dr. Christison, that lead colic, rarely met with before in that city, then broke forth frequently, and in a violent form. As it appeared chiefly in the autumn, it was thought to be due to the corrosion of the lead being *hastened by the decaying leaves* which then lay on the roofs. Doubtless a sound reason.

Can it be then a question, whether salts and organic acids will prevent the action of rain water on lead? All experience shows, what chemistry demonstrates, that these salts promote its solvent power.

But are the salts of natural water, the salts of river and lake, like the salts of rain water? It has been shown how large a quantity is annually contributed to Lake Cochituate and its tributaries. This must be diminished by the amount of the annual evaporation and drainage. There is no reason to suppose that the amount of salts removed from the land by evaporation, is less than by an equal amount of evaporation from the ocean. The earth is an evaporating ocean. It is a great reservoir of salts and the percolating rain dissolves and carries seaward that amount of salts which decaying plants, during their growth, withdrew from decomposed and decomposing soil, an amount for which they owe not the sea. This amount, carried by the drainage of the land into the lake, may be set partly against the loss

by evaporation. It were well perhaps to inquire if the total amount of salts in the lake water is not greater than that which annually falls in rain, diminished by the amount lost by evaporation and drainage.

At the highest computation of the Commissioners of 1845, 10,000,000 gallons per day is the amount supplied by the lake.

This contains as rain, salts 1.603 grains per gallon = 2,290 pounds. The published reports of 1837 and 1845, of the analyses of Dr. Hayes and Prof. Silliman, Jr., give 3.030 and 3.163 grains, or an average of 3.099 grains in 100,000 parts = 1.809 grains in the gallon = in the daily supply to 2584.28 pounds, or an excess over the salts in rain water of 294.28 pounds. It should be noted, that the analysis of 1845, is of water taken near the proposed outlet. Deeper water of the same year afforded Prof. Silliman, Jr., 3.37 grains per gallon, whilst the analyses by Dr. Jackson in 1834, and 1845, of water from the outlet, give an average in the 100,000 parts of more than double those of 1837 and 1845, as above quoted, and therefore exceeding per gallon that of the deep water of 1845.

The greater amount of salts in the deeper water is analogous to the facts relating to the salts of the Mediterranean, the tides in estuaries, and the water of the deepest sea, saltier at the lower depths. The results of 1834 and 1845 seem to indicate that some cause had occurred to produce a mingling of the higher and deeper strata of water. If this should be found to have a periodical recurrence, that fact will have an important bearing on the question of the amount of salts furnished at the outlet. There is, however, a cause which must annually bring up the lower strata. The lake will not be frozen over till all its water is cooled to at least 39.5 deg. Fahr. Below this the water becomes lighter by cooling. Till it has arrived at this point, the upper and lower strata will counterswim. The ascending and descending currents will be arrested only during the short period, at which the temperature of the whole mass of water equals that of the lower strata. This rising to the surface of the deeper water, so highly salt-charged, must produce a difference in the results of experiments on its lead-solvent power, according to the season. So, likewise, its effect on lead pipe.

But whatever may be the amount of the excess above that of rain water, it is due to the salts and organic acids derived from the earth.

These analyses have shown abundant salts in lake water, and proved their similarity, almost their identity, with those of rain. We might justly then infer that their action on lead would be similar.

We are not here to grope in conjecture, nor feel the way by right inferences, nor are we left to the light of direct experiment.

During the year 1846, I was requested by a medical friend to examine some Croton water, drawn directly from the street main, through

a leaden pipe, into the house for family use. Disorder, supposed to arise from lead, had appeared in more than one member of the family. It was this which caused a chemical examination to be requested. The result of my examination showed lead in solution, with the following classes of salts, per gallon : —

Alkaline chlorides with crenic acid	0.6149
“ sulphates and organic acids	1.2298
Lead oxide, silica, carbonate of lime and magnesia, alumina and apocrenic acid	1.5373
	<hr/> 3.3820

The water was discontinued, and the health of the patients restored.

Here, then, we have direct proof of the solvent power of lake water on lead pipes. This is not a solitary instance. Others, better skilled, have also detected lead in Croton water, drawn from the iron main through lead, and that very early after its introduction into the city.

There is here a circumstance to be noted. The ordinary electrical relations of lead and iron indicate that the first would not be attacked in contact with the last. But it is well known, that iron water pipes are rapidly corroded and lined with mammillary and almond-shaped concretions of iron and organic acids. Here the electrical condition of iron becomes changed, and the lead is now subject to be acted on. Were the lead lined with tin, that combination would still allow the lead to be acted on, and probably even through the coating of tin, imperfectly applied as it must ever be.

But independent of all electrical influences, the presence of the peroxide of iron, such as exists in the concretions above named, hastens the corroding action of water on lead. These excrescences are continually produced, and concussion and other causes detach them; their powdery consistence allows them to be easily disintegrated, and to become diffused in water, and so this peroxide of iron will enter the lead conduits.

Now, the metallic lead deoxidates the peroxide of iron, an effect even known to be produced by other metals. Oxidation of the lead is more energetic than by the air in water; add to this, that a large portion of the carbonic acid existing in the water, perhaps the whole, has been withdrawn by these iron concretions, and hence the coat of carbonated oxide, which would otherwise be formed on lead, and whose presence would impede the action of water, is thus prevented, and the naked oxide is at once presented to the solvent power of the water and its acids. This iron rust is diffused in water, and in the instance of the Croton referred to, so highly tinging the water when drawn into a marble bathing tub, as to lead to the belief that the water was charged with

iron. Its presence acts like a stream of oxygen, and thus it acts to hasten corrosion and solution of lead pipe.

In proof of this effect, the singular case reported to the British Association, may be here adverted to.

Spring water had been running, for a period of many years, through lead pipes, and without any perceptible action on the lead tank into which it was received; but when the water was afterwards conveyed through iron pipes, the tanks were rapidly corroded, lasting only one tenth of the time they formerly were preserved. In this case, the water had flowed from and into a leaden reservoir, through lead pipes, without known metallic impregnation, for sixty years. Yet when conveyed farther, a long distance in iron pipes, contained lead in solution, and destroyed the *bottoms* of the tanks in five or six years. The lead was found in the water of the delivering and receiving tanks, and of the iron pipe.

Now let us for a moment cast our eyes over the published Reports of the analyses of Cochituate water — compare its similarity of salts with those in rain, and its chlorides and organic acids with those of Croton water. Let it be recollected what chemistry has taught ought to be its effects, and what has been the effect on lead of rain and Croton water, accelerated as the last has doubtless been by contact with iron. Let it be called to mind, how baseless is the hope, that incompatible salts will act as protectors, and prevent that action, which science shows, experiment teaches, and actual experience proves, has ever occurred and will ever recur; and then let it be asked, whether reason and common prudence do not forbid the use of lead for the distributing pipes of Cochituate water? There is but one answer to this question. My convictions are decidedly against the use of lead, pure or alloyed, or tin-coated, for conduits for water to be employed for domestic purposes.

I presume that I need not enter into any detail of the effects of lead water on health. This whole question is based on the principle generally conceded, that it is a poison, producing grave diseases, ending often in death.

With the most profound regard,

I am your obedient servant,

SAMUEL L. DANA.

On the other hand, there are many cases, especially in the primitive regions of New England, where spring water has been introduced through lead pipes into villages for domestic use, and

neither on its first introduction, or on long use, as the resident physicians affirm, have *colic* or *paralysis* been noticed among the inhabitants using the water thus transmitted. In some of these aqueducts, the water flows continuously into cisterns, the surplus water escaping by the overflow pipe, and the water being dipped out for family use. But here also, there is formed a slight coat of oxide and carbonate of lead, and the pipes when examined have shown decided evidence of action of water; this action, slight as it is, after years of contact, evidently must have been years going on. Waters, whose action may be said to be infinitely small, will not in a few days or months either deposit a thick coat, or show those decided marks of erosion, without which deposition does not and cannot occur. It must never be forgotten, that a lining coat in a lead pipe is to be taken as evidence of undoubted action of the water. A pipe coated, is a pipe corroded. Continued action is evident from an increasing deposition. Where this is slight in a long course of years, it may be rightly inferred, that there slight action has been continually going forward. The question is not, whether disease has occurred from the use of the water, but whether corrosion has ceased. That is the point under consideration. Corrosion being proved, unless the mass of evidence in this work, of disease being caused by swallowing lead particles, is set aside, disorder follows as a corollary. That may be considered hereafter; for while disease, produced by water from lead pipe, may be adduced as corroborative evidence of action, yet its absence can never prove non-corrosion. This evidence is however entitled to great consideration, and were lead disorders, in all their forms, well understood, such evidence from skilful observers although negative, would in its cumulative mass amount to that having a positive character.

The anomalous cases of apparent non-action, derived from the absence of disease, are of great value. They are the exceptions to the general rule, that water flowing in lead pipe causes disease. They are not proofs of the total cessation of action, and as exceptions, the evidence they may afford of non-action can be applied only to each case as it has occurred.

From whatever cause the apparent absence of action upon lead in any marked degree arises, the fact that certain spring waters possess this quality is unquestioned. The cause is one of great philosophic interest, but at present the fact is that which

demands attention. The question in the present state of science can be determined only by experience, whether a given spring water will or not act, and continue to act, on lead pipe used as its conductor.

That the amount of action in many cases is so slight, that no very perceptible erosive effect has been produced on the pipe in the long period of fifty or sixty years, is not denied. That the water so conveyed has seldom produced ill effects attributable to lead impregnation, seems equally well established, though till it is determined what are lead diseases, this question has not the force of that dependent on the corrosion of the pipe. That the coat which is deposited on the interior of lead pipes, transmitting spring water, will vary much in its composition, according to the quality of the salts which the water contains, and will depend on their character, is almost self-evident. Where carbonate of lime and carbonic acid exist abundantly, there a rapid deposition of a coat of carbonate of lime and salts of lead will occur; and when lime is absent, so generally carbonic acid is abundant, and the deposition consists of oxide and carbonate of lead, more slowly formed, but yet to some degree impeding the action of spring water.

In all limestone districts, the water will probably act slightly on lead, corroding it so slowly that pipes of this metal will be found thickly incrustated, yet still acted on, though the quantity of lead dissolved is so infinitely small, that ordinary tests do not detect it. Yet the limestone waters do act on lead; Tanquerel states that fact. (See Causes of Lead Colic.) They act till the coat of carbonate of lime is formed, and hence, as Tanquerel has quoted from Devergie, the inhabitants of some towns, where lead aqueducts are used to supply water for fountains, were seized with colic, on using the water which first flowed through the new pipes. It is to be regretted, that no recorded examination has been made of the water flowing in the Paris lead pipes, to detect there the presence of this metal. Not only is chemical analysis wanting to the decision of this question, but, as Tanquerel states, he never observed *colic* produced by the use of lead aqueduct water in Paris, it may be inferred, though not proved, that the fountain water of that city contains no lead. That the chief source of the water there used after passing through lead is from springs charged with carbonate of lime, Tanquerel has distinctly affirmed, and to this cause he attributes the "*difficult*" action of that water on lead.

And here it may be proper to discuss that highly important fact stated by Tanquerel, that he has not been apprised, that colic has ever been induced by the use of water from the lead pipes in Paris, supplying public or private establishments. The fact is conceded, not in the limited sense of *colic* only, but in that broad extent which includes *all* lead maladies. It is not to be supposed, that one so deeply skilled in all the phases of lead disorder as Tanquerel, would have confined his observation to colic only. It may be inferred, that he would have recognised the minutest shades of lead disease, and attributed them to lead water, had there been evidence of such a cause. The question appeals to experience. This argument, rightly applied is valid, and wrongly applied will always have great weight with those who have not examined all the circumstances. Nor is it on Paris experience only, that this argument in favor of the safety of lead pipe depends. Similar inferences may be deduced from like facts in other places, where lead pipe is used, though the force of such conclusion must depend very much on the degree of knowledge of lead malady, possessed by those who report the facts. Yet this argument for the safety of lead, applied as a practical rule to all water, is fallacious, and more specious than solid. It may be true of water of particular quality, but not true of water of a different constitution. It is not true even for the same water, at all times.

Allowing the full weight, which observations have shown, to the influence of protection, so-called, dependent on the composition of the water, we are deprived of this resource, where, as is well known, the two seasons of spring and autumn cause changes of composition, in the sources of supply. Impunity from lead disease, where lead pipe is used, may be interrupted by unusually high temperature, or copious rains. Keeping in view the capriciousness of our own climate, the varying composition of pond water within certain limits, and the influence of temperature, the protective energy of one week, feeble as it is in such cases, may be, and has been unknown at another.

It has been noticed, that, from Tanquerel's remarks, it may be inferred, the fountain water of Paris, distributed by lead pipes, belongs to that class which Christison considers eminently protective. The general character of Parisian water is, that it is highly charged with *carbonates of lime* and other earths, or with *sulphate of lime*.

The actual amount of solid matter per four litres, or about a gallon,		Grammes
is, in the Seine, before its junction with the Marne, . . .		0.7140
Do. in the Seine, in Paris,	} carbonate and sulph. lime, {	0.6820
Do. in the Seine on leaving Paris,		0.7240
Do. Canal of Ourcq, near Paris, sulph. lime		1.8084
Do. Spring of Arcueil (fountain of the Institute, Paris), . . .		1.8640
Do. Springs of Belleville and Menilmontant, near Paris, . . .		6.5960
Do. Well of Grenelle, in Paris,5720

Reducing these numbers to grains, the quantity per gallon is,

Carbonate and sulphate of lime in the canal of Ourcq, and fountain	Grains.
of the Institute,	29.1417
Carbonate and sulphate of lime in the Seine, Paris,	average 10.8613
" well at Grenelle	8.8374

Sulphate and carbonate of lime are the chief salts in Paris water. These, experiment has shown, are the great protective agents, and the results of experiment have been here confirmed by experience, so far as the negative evidence of non-appearance of disease proves non-action of water on lead.

Another circumstance must here be considered, the average daily amount of water used by a Parisian, compared with the average used by an inhabitant of other places. This is always an important element in the question, whether lead water causes lead disease. All calculations on this point are somewhat vague, and the total amount supplied to a place, or to each water taker, or tenant, is usually divided by an assumed number of inhabitants of the locality. So much per head includes all that used for the various wants of the inhabitants, domestic, manufacturing, washing the streets, for stables, gardens, baths, &c., and the accidents of fire. On these data, the average to a Londoner, in its best supplied districts, is 32 gallons.

To an inhabitant of Edinburgh,	19	"
" " Glasgow,	37	"
" " Philadelphia,	30	"
" " London,	20	" average.
" of Vienna, Grenoble, Montpellier,	16	"

In France, engineers allow to each inhabitant, 5 gallons.

Low as this amount is, it exceeds the *actual consumption* by at least one half. Dupasquier, (*"Traité des eau de Source et de Riviere, &c."* as quoted in *Ann. d'Hygiene*, t. xxv.,) states that each inhabitant of Paris consumes daily only ten litres, or about two and a half gallons. But since the canal of Ourcq has been

accessible, this quantity, according to Bourchardat, has been increased, but as will be presently shown, from actual statistics, this is probably near the true amount. The other numbers, if reduced one half, will doubtless exceed the actual consumption of an individual, that is, the quantity used for domestic purposes.

Let now the source of the Parisian water be examined. The great source is the canal of Ourcq, supplying, according to its engineer, M. Girard, about 20 millions of gallons daily, (4000 *pouce d'eau de fontainier*,) which M. Genieys, the engineer attached to the service of distribution, says is all "appropriated for fountains, and for cleaning streets, so that water is raised from the Seine for domestic use. The actual quantity so used does not exceed 200 inches," (*pouce*,) or 1,013,168 gallons per day, or about one gallon for an individual. Look at the mode of distribution of the Seine water. It is bought by the carriers at the pumps, and retailed by them to consumers from carts and hogs-heads, or from buckets hung to straps from the shoulder yoke of distributing porters. "To supply the want of Seine water, on account of its cost, pumps are employed in nearly all private houses, and spring and well water is used, although it does not possess qualities suitable for mechanical industry." (M. Genieys, as quoted in Mr. L. Baldwin's *Report*, 1834.) It is evident, therefore, that the great mass of the Parisians use water that has not passed through lead. The fountains and public establishments are supplied by the canal of Ourcq. These alone have a lead service pipe connected with an iron main, proceeding from the subterranean aqueducts of stone masonry. The quantity of water so supplied, will not, on the estimate of Dupasquier, increase the average to more than two and a half gallons to each person, or 1 gallon from the Seine, $1\frac{1}{2}$ gallons from the canal of Ourcq, springs and wells. The canal water is allowed on theory, experiment, and observation, to be in the highest degree protective, not only by the quality, but enormous quantity of its salts, amounting, as has been shown, to nearly 30 grains per gallon, or one 2000ths of its weight.

That lead diseases are not caused in Paris by the use of its water, which has passed a service pipe of lead, is accounted for not only by the comparatively small quantity used, but by the fact of its highly protective quality. A similar explanation may be given of the alleged non-appearance of disease from lead pipe water in other great European cities, and this will apply, even allowing for the larger amount of water there consumed.

London is supplied from the Thames and from the New River. The last derives its main source, at least two thirds, from the Chadwell spring, the other one third from an arm of the river Lea, the source of which is near the Chadwell spring. The geological features of this locality will give the water of New River a protective quality. Chadwell spring is situated on the upper chalk, and the Lea and its tributaries rise in that formation, while the New River flows in part through that, the plastic and London clays. Dr. Clarke speaks of the New River as containing hardly any impurity but *bicarbonate of lime*. The Thames water has been shown above, from the experiments of Taylor, to be highly preventive of action on lead, and has itself only the feeblest effect on that metal. It contains about 12 grains solid matter per gallon, about $\frac{1}{5000}$ to $\frac{1}{7000}$, chiefly carbonate and sulphate of lime. The Edinburgh water is proverbial for its purity. The saline ingredients are about 4.88 grains per gallon, $\frac{3}{4}$ ds being lime and $\frac{1}{4}$ sulphates and muriates of soda, lime, and magnesia, or about $\frac{1}{12000}$ of the weight of the water. It is truly spring water, collected far beneath the surface of the ground, and throughout its passage of nine miles to the city, is never exposed to weather or light till drawn for use. Christison has shown how slight its action is on lead, but like all spring water, as he has proved, it still acts so as to render its retention in the pipes, a number of days, unsafe. And Dr. Thomson says, during the years he lived in Edinburgh, he always found lead in suspension in this water. This fact shows decidedly continuous action.

If the waters which supply cities in our own country are examined, not experimentally only in the laboratory, but by observation of their effects on the lead pipes used for their distribution, it will be found that their action is slight from the same cause which prevents action in Paris, London, and Edinburgh. If the chemical analyses of several of these waters are compared with that of the constitution of the waters which supply those foreign cities, it will be seen that they are protective from the abundant quantity of *carbonates of lime and magnesia*. More than half of the solid contents of Schuylkill and Croton water is composed of *carbonates*, as the results of the analyses of Messrs. Booth and Boye show.

James River is the drainage of a large limestone region, and, like the Ohio, is essentially *calcareous water*.

It may be inferred, that as the protective power decreases, action increases. Hence lake and pond water, situated in primitive districts, surrounded by a country, the drainage of which carries into its natural reservoir no great proportion of earthy carbonates or sulphates, will almost surely act energetically on lead. The feeble power of its minute quantity of protective salts will be neutralized by the great quantity of carbonic acid which such waters often contain. It is to this cause that is to be attributed the more energetic action of Croton, compared with Schuylkill water. It is to this cause the continued action of Croton water is due; it is probably the cause of the enduring action of Jamaica Pond water, and which will cause all similar water to act continuously, though with varying force, according to its quantity and the character of the protective salts. To show at a glance what action may be expected, the following table of the solid contents of a gallon of several waters, the classes of salts, and the quantity of carbonic acid which a gallon contains is presented.

	Paris, Canal of Oureq.	Seine.	Schuylkill.	Croton., purest state.	Thames, purest state.	Cochituate.
Carbonic acid, cubic inches	3.879	17.48	..	10.719
Solid matter	27.898	10.622	4.080	4.998	10.925	1.220
Carbonates, chiefly lime	10.213	6.829	2.859	4.060	.8668	.301
Sulphates, chiefly lime	8.930	2.451	.560	.000	0.840	.102
Chlorides	2.33 (mag.)	0.466 (mag.)	.153	.193	1.120	0.177
Organic matter	traces	traces	.036	.276	0.392	0.500

The solid matter in Jamaica Pond water is less in quantity than that of Cochituate, but is of similar quality. That disease is not produced by water, where its protective powers are shown by the above table to be feeble, is still an open question, which can be determined only by the exact observations of physicians accurately and minutely acquainted with all the varied forms of lead maladies.

That such diseases do occur from the use of Croton water, has been proved as fully as the cause of disease can be proved. If water, the analysis of which shows nearly five grains of solid matter per gallon, four fifths of which are carbonates of lime, highly protective, acts continuously on lead, causing disease, with what reason can it be expected, that pond water, in which the solid contents per gallon are only one fourth, and the protective power of which is only a tenth of that, that of Croton water will be harmless? If the seventeen cubic inches of carbonic

acid in a gallon, almost neutralizes the great protective force of four grains of carbonate of lime per gallon, what but utter annihilation of protection can be expected from the action of ten cubic inches of carbonic acid, on forty hundredths of a grain of protective salts? Certainly disease may be anticipated from the use of such water transmitted through lead. General disease, pervading whole communities like an epidemic, is not to be looked for, though such occurrences have been noticed, on the use of water so transmitted, not only on the first introduction, as quoted by Tanquerel, but several months afterwards. If but one case of disease in a thousand, can be traced to the use of water, poisoned by flowing through lead, the use of that metal should be discouraged by all, who by their official station, or professional character, are the especial guardians of the public health.

EXTRACT FROM A LETTER WRITTEN BY JOHN C. DALTON, M. D.,
M. M. S. S.

Lowell, April 24, 1848.

DR. DANA,

Dear Sir: — You expressed a wish the other evening to be apprised of any facts, within my experience, of the deleterious action on the system, of water impregnated with the salts of lead from transmission through pipes of this metal. During the years 1838 and 1839, cases were of frequent occurrence in the practice of many physicians in this city, of derangement of the functions of the stomach and bowels, more or less severe, of a somewhat peculiar character. They were marked by constipation, impaired appetite, emaciation, frequent attacks of colic, a dingy, sallow aspect of the skin, approaching to the bilious, but unattended with yellowness of the conjunctiva, general loss of strength, wandering, shooting pains of the limbs, which in some of the severer cases, became perfectly paralyzed. The attacks were sometimes sudden, but for the most part supervened gradually.

Although there were here and there cases in other parts of the city, the larger majority, and the most severe and protracted ones, occurred in that portion of it embracing what is called Chapel Hill.

They were generally very intractable, yielding very imperfectly to judicious treatment, (in the then ignorance of the cause,) and returning in all their severity as soon as these measures were intermitted. In some cases, several, and, occasionally, all the members of a family would become similarly affected in different degrees. In one family,

under my care, whose supply of water was through lead pipe, four hundred feet in length, all the members were attacked, the transient ones with constipation, colic, &c. ; the more permanent ones with the severer symptoms; going on in one case to perfect paralysis of both lower extremities. Domestics residing but one week in this family became similarly affected. From the resemblance, nay identity, of many of these cases, to the affections of painters and others, whose employments expose them to the action of lead, suspicions were very soon awakened as to the cause; analyses of the water, in some of the suspected wells were instituted, principally, I think, by yourself, and notable quantities of lead in almost, if not quite in every instance detected; the pipes, on examination, exhibited unequivocal marks of the solvent action of the water upon them; their surfaces being in some places very much thinned, and in others riddled with perforations. The matter assumed so much importance that a memorial was addressed by the physicians to the City government, requesting that measures might be forthwith instituted for its thorough investigation. This memorial was favorably received, and a report embodying the results of chemical research subsequently given to the public. The consequence was, that, to a great extent, lead pipes were removed, and others of iron or other material substituted; from this time, obstinate and protracted cases began to recover permanently; new cases became rare, and for the last several years have been uncommon; but where they do occur, are invariably traceable to the cause above assigned. A year ago, a lady removed from Tewksbury to a residence on Chapel Hill, and although previously in the enjoyment of good health, became soon affected with symptoms bearing unequivocal evidence of their saturnine origin. After having been under treatment unsuccessfully pursued for months, under different practitioners, she recovered rapidly under simple treatment, on withholding the use of the water of the house, which was brought from a considerable distance through lead pipe. About three months since, I was called in consultation, by an intelligent physician of Westford, to a protracted case of a similar character with the above, which he had just begun to suspect had a similar origin, from discovering the characteristic "blue line" at the edge of the gums, and from the fact, that lead pipe had been not long before substituted for wood, for the supply of water to the family. I at once coincided with this view, and the result was, as I have since learned, a speedy and perfect recovery.

I have quite recently had under my care, a very obstinate case of paralysis of the extensor muscles of the arms, in a female, precisely resembling the affection not uncommon among painters, which is accurately described and drawn in Pemberton, "On some Diseases of

the Abdominal Viscera." This case also originated on Chapel Hill, and was traceable to the long continued use of lead water, but still remains uncured, notwithstanding the removal of the cause, and the adoption, from time to time, of every variety of treatment, irregular as well as regular, which seemed to promise relief.

These and many other cases of more or less pronounced character, which have come under my observation, have impressed me strongly with the injurious influences of this poison, thus insidiously introduced into the system; and I have for many years past exerted my influence to prevent the use of lead pipe, as a medium of conveyance for water to be used as a beverage.

I believe it to be a prolific cause of many anomalous cases of deranged health, when the more prominent symptoms do not appear, (by which they might be readily traced to their true cause,) and have been strongly inclined to suspect, that it may often be at the foundation of the thousand and one forms of the nervous affections, which afflict modern life, and perplex and puzzle the modern physician, by their Protean forms and intractable character.

LETTER FROM HORATIO ADAMS, M. D., M. M. S. S.

Waltham, June 9, 1848.

DEAR DOCTOR,

Agreeable to a promise I made in conversation with you the other day, I send to you a brief history of the sickness of Mr. Samuel Maynard. My account will be general, giving the principal points of the several attacks to which he has been subjected, together with their sequels, presuming that this will be more satisfactory to you than the more minute details of the case.

I remain, my dear sir,

Very truly yours,

H. ADAMS.

- For several months previous to the summer of 1838, Mr. Maynard had been employed in repairing the lead chambers at the Newton Chemical Works. In the month of August, I think, he had a very distinct, and somewhat severe attack of painters' colic; the severe pain in the back and bowels, and the constipation yielded in a few days under the very liberal use of cathartic medicines; leaving, however, a sense of general weakness, with a dull pain in the back, which, at times, extended through to the bowels, with occasional, but not frequent, griping. These symptoms, after a few weeks subsided, and he resumed his ac-

customed work, fully aware that it was his constant exposure to an atmosphere charged with lead which caused the sickness from which he was just recovering.

This attack of colic was followed by a sense of weakness in the muscles of the extremities, particularly in those of the arms. There was, also, considerable tremor of the hands, which rendered it very difficult for him to write, and this tremor was frequently attended by a slight spasmodic action of the muscles of the arms; it was never general, and was shown by a sudden twitching of the hands and fingers. This sense of weakness in the muscles, the tremor, and the spasm, have never subsided. They exist at the present time.

Nothing particular occurred after the attack of colic in 1838, other than what has been above described, up to the winter of 1842; during which time he continued at intervals his occupation of plumber. In the winter of 1842 he was attacked with acute inflammation of the synovial membranes of the right knee. This yielded, without much difficulty, to leeching, cupping, and vesication, and the limb, after a few weeks, seemed to be nearly as well as usual. In June of 1842, the left knee became affected with the same difficulty. At this time I was absent for several weeks on a journey, and he unfortunately fell into the hands of an irregular practitioner, whose treatment consisted, as the patient subsequently informed me, of baths, lotions, and ointments. The inflammation was not subdued, but passed into the chronic form. He first came under my observation two months from the commencement of the disease. At this time the knee was very much swollen, in consequence of the thickened and distended state of the synovial membranes. The difficulty was partially relieved, but not entirely removed, by a rigid course of leeching, cupping vesication, and subsequently by bandaging. The knee now is somewhat contracted, not much enlarged, but very weak, and, at times, painful; he is still unable to walk without the aid of a crutch or cane. Mr. M. gave up his occupation of plumber soon after the disease commenced in the left knee.

He had no new difficulty till 1844, when both wrists began to swell, and were very painful. When I first saw him, they were both considerably swollen, and at times painful. After a close examination, I was entirely satisfied that the synovial membranes were the seat of the disease. In the course of about two weeks a partial paralysis of the muscles of the limbs very gradu-

ally took place. On inquiring, I learned that for ten or twelve days previous to the commencement of this attack, he had been painting with lead, when he was obliged to desist, in consequence of the pain in his wrists. The swelling at the wrists, and the partial paralysis of almost all the voluntary muscles have never disappeared; the arms have suffered more than any other part of the body; he is now unable to raise the right hand to his head, and the motions of the left are very much impaired.

The following facts in this case seem to me to be worthy of notice, as connected with the question of the effects of lead on the human system. In 1838, after an exposure of several months to the influences of lead, there was an attack of painters' colic, followed by weakness, tremor, and spasm of the muscles. This weakness, tremor, and spasm of the muscles has continued to the present time, (ten years.) During the first four years of this time, there was almost constant exposure to the direct influences of lead, when (in 1842) inflammation of the synovial membranes of the knees ensued, from the effects of which he has never entirely recovered. Two years from this time (in 1844), after a direct renewed exposure to lead in painting, there was inflammation of the synovial membranes of the wrists, which was soon followed by a partial paralysis of the voluntary muscles, from which the patient has never recovered. From the close of 1842 to the present time, there seemed to have been no exposure to lead, except from painting ten or twelve days in 1844; but on inquiry, I learned that the water, which was used for drink and culinary purposes, was brought into the house by means of a lead pipe. If this water should be found to contain lead, then has exposure to lead in a form likely to produce disease been constant for the last ten years. I have sent you a bottle of the water for analysis.*

As to the causes of these several attacks of sickness, there of course can be no question that the first, (the colic) was caused by lead. The third, the synovial inflammation at the wrist, and the subsequent paralysis,† seems to me to have been directly

* I found lead in this water, by the usual test. — S. L. D.

† What I have spoken of as paralysis seemed to be rather a stiffness than a paralysis of the muscles; they did not appear to obey the will readily; for instance, the muscles would be very slow in contracting, and once contracted, would be equally slow in relaxing themselves. They were incapable either of rapid or extended motion.

consequent on a renewed exposure to lead in painting; the character of this attack would certainly lead to this conclusion. May it not then be more than probable that the second attack, the synovial inflammation of the knees, was produced by the same general cause? Taking into consideration the analogous character of the second and third attacks, (both synovial inflammations) it to my mind leaves strong grounds for suspecting it.

Several other cases of sickness have occurred under my observation within the last five or six years, which could only be attributable to lead. The cases were among the inhabitants of a certain section of the town where lead pipe had been introduced for the purpose of conveying water into their houses. Two of these cases were so anomalous in character that I shall give to you the details.

Two sisters, one the mother of a large family, the other unmarried, are the subjects of the following remarks. The husband and children of the married sister constituted the remainder of the family. These sisters were attacked both at one time and in a similar manner.

They first began to experience some difficulty in walking; there was a stiffness or lameness of the muscles, they could not advance the feet as far as usual; to use their expression, "they could not get along," they felt that their limbs were soon tired. This state of things increased for about three weeks, when they came under my observation. I found them indisposed to much motion, not so much from weakness, though they were somewhat reduced, as from an inability to call the muscles into action, to use their expression, which was a significant one, they were "clumsy, their limbs were stiff and lame." Within the last few days their faces had become somewhat swollen, this swelling indeed seemed to pervade every part of the body; there was also an erythematic redness of the skin generally, but more particularly in the face; so great was it that I suspected that they had been using some nostrum containing arsenic, the inflamed and swollen appearance of the face so much resembled what is sometimes seen when that medicine has been taken till its specific effects are strongly produced, but they assured me they had taken nothing of the kind. The appetite was impaired, and there was at times considerable griping pain in the bowels, accompanied with looseness; in one of the patients it was so

great as to require opiates to restrain the frequency of the discharges. This lameness in the extremities was very troublesome, and continued for a long time. It was at least four months before these patients entirely recovered. During most of this time they were able to sit up and to move from one room to another, but were unable to attend to their duties in the family. Several members of the family were during this time similarly affected, but not to the same extent, either in the severity or duration of the disease.

While making investigations into the cause of this very peculiar sickness, I learned that the family, for the six months previous to these attacks of disease, had been using water, both for drink and culinary purposes, which was brought from a distance through lead pipe; this led me at once to suspect this as the cause of the difficulty. On examination, the water was found to contain lead. The family were at once informed of the fact, and directed to discontinue the use of the water from this well; the disease, which till this time had been getting worse rather than better, soon began to subside, and in about two months the patients were comparatively well.

These cases will, I think, show that colic is not by any means the only form of disease produced by the habitual use of water containing lead in minute quantities.

I will further add, that it is now about one year since the above difficulty occurred. The family have never since that time used the water from this well, and have been free from disease."*

The following cases were received from Dr. Adams as this sheet was going to press, July 11th.

Case I. In 1839, U. B. Stearns had an attack of lead colic, in consequence of using cider which was impregnated with lead.

* Mr. Maynard's first attack of lead colic was in April, 1833. He was then the plumber at the works of the Newton Chemical Company, to which I was attached as chemist. He had been absent a few days, being unwell, and met me on my way out from the works, which I had just visited for the last time previous to departing for Europe. He gave me this account a few days since in conversation, adding, that I then told him, after he had described his symptoms, that he had had an attack of painters' colic. The whole had entirely escaped my recollection. It is a striking instance how doubtful is the evidence of the existence of disease, which depends on this source. — S. L. D.

This was soon followed by a partial paralysis of his extremities, from which he has not yet entirely recovered. In 1845 he experienced a second attack of the same disease, in consequence of a renewed exposure to lead in painting for a day or two, and subsequently sleeping in a room soon after it had been painted. This attack was less violent than the first. During the two last years he has repeatedly suffered from severe pains in his knees and ankles, and at times in his wrists; he has often been so lame as to be unable to walk without great suffering. His step is infirm and tottering, his countenance pale and haggard. He is often unable for weeks to oversee the work about his farm. He suffers much from constipation, and its legitimate attendant, the piles.

He consulted me several weeks since, in consequence of the above state of his health, when I learned that three years since he placed lead pipes into his well. On analyzing the water from this well, it was found to contain a small quantity of lead, sufficient, in all probability, to keep up the difficulty already commenced in his system, which seemed to be rendered much more susceptible to its effects in consequence of the former severe sickness from the same cause. There has been a decided improvement since he discontinued the use of this water.

Case II. In February, 1848, A. B. was seized with an attack of lead colic, a well marked and severe case; had had a slight attack several months before. He has for the last two years used water drawn from a spring coming out upon the surface of the ground about four hundred feet from his house; the lead pipe leading to this spring has been in use six or seven years; the water from it was found, on analysis, to be very strongly impregnated with lead. The patient gradually regained his health after leaving off the use of this water.

This is the only instance I have seen where disease has been produced by lead in the water, taken through lead pipe from a spring opening upon the surface of the ground.

Case III. Six years ago, W. P. Child was several weeks sick with colic, caused by sleeping in rooms which had been newly painted. Since his recovery from this sickness, he has been well till the last two months. Four days since, (July 6th,) he called to consult me in consequence of feeling, as he said "just as he did for a week or two before he had the attack of lead colic six years since;" and he was very apprehensive that he was about to get an attack of the same disease. He complained of frequent

pains in his bowels, great constipation, pain not relieved by evacuations; did not feel strong to work. I found, on inquiring, that the water used by the family for the last five years had been drawn through lead pipe. He had himself suspected this to be the cause of his trouble, (as there had been no other exposure to lead that he knew of,) and brought me a quantity of the water for analysis. I found it to be strongly impregnated with lead. Two days after this, (July 8,) the father and mother of this patient, living in the same family, consulted me in consequence of a great weakness in their knees and ankles, which they had felt for the last three months; it had steadily increased to the present time. They described it as a weakness and stiffness of the legs; it was with great difficulty they could walk any distance or get up stairs; the father was obliged to give up labor in consequence of it. I considered lead water as the cause of the difficulty, though they had not suspected it themselves. My direction to all of them was simply to discontinue the use of the water from this well.

EXTRACT FROM A LETTER OF SAMUEL WEBBER, M. D.

The following letter deserves especial notice, as showing the continued erosion of lead pipe by spring water. I have examined the specimen of pipe referred to in the letter, and find it is eroded, as its incrustation would indicate. This incrustation would not occur unaccompanied by action on lead in a water of the character of that here used. Incrustation is the consequence of that action, and the fact of its continuance is well shown by the different states of the supply and flow pipes. The observations are interesting, as a record of one of those cases where the action of spring water is so slight as to lead to the opinion that there is no action, and that opinion may be strengthened by the non-appearance of disease, though that may be due in part to the effects of a constant flow of water through the pipe.

Charlestown, N. H., June 8, 1848.

DEAR SIR,

Yours was received yesterday, and as you say, "*unless you have examined the water of any pipe, say some months after the water has been flowing through it,*" I concluded that it will not be necessary for me to repeat any analysis, as in all the cases that I reported to you formerly, the pipe through which the analyzed water had flowed had

been in use at least several months, and in most cases, I think, from one to three years. However, to put it in your power to answer more completely your own queries on the positive action of our water on lead, I went to one of my friends, and obtained permission to cut off a small section from the end of one of his lead pipes now in use, and which has been in constant use for about 3 years, a part of which section I inclose to you. It was cut from a supply pipe rising through the bottom of a cistern, and terminating about six inches below the surface, the orifice of the waste pipe being situated about that much higher than that of the supply pipe. You will perceive that this piece of lead is well coated both within and without with — what I shall leave to your wisdom to determine — either some mineral deposit from the water, or an oxide or carbonate of the lead itself, or a mixture of both as I conjecture. The waste pipe also leading down perpendicularly through the bottom of the cistern, but having its orifice just below or upon the surface, and occasionally when water is dipped out of the cistern projecting from one to several inches above it, happens, fortunately, in this case, to have been renewed but a few months since, and its surface is much less discolored than that of the supply pipe, by which you will see that whatever the substance may be to which this discoloration and crust is owing, or whatever action produces it, the action and its effect increases at least in some degree, or within some limits, with time. This will answer another of your questions, unless the examination of the specimen gives you reason, as I do not think likely, to conclude, that it is a mere mechanical deposit, without any chemical action of the water on the lead.

I know of no facts showing that water ceases to act on lead, and can conceive of none, saving that the action should produce an insoluble incrustation impermeable to water.

With regard to diseases produced by *water* impregnated with lead, I cannot say positively that I have ever met with any such.

I have, indeed, had to contend with painful affections of the bowels, colic, constipatory, and inflammatory, in those who used the water conveyed in lead pipes; but, upon careful reflection, I do not think that these cases were more frequent in such, than among those who used water conveyed in logs, or drawn from a well, or raised in a pump. Nor have such attacks followed each other with the pertinacity appertaining to those caused by the poison of lead; but though the use of the same water has been continued, the attacks have either been single, or if repeated in any individual, they have occurred at distant periods, and might in most, if not all cases be readily, and in all probability truly, referred to particular circumstances occurring at the time.

In our water establishments the water does not stay in the pipe, to be

drawn thence for use by means of a stop-cock, but runs continuously into a cistern, and is as continuously conveyed out whenever the cistern is filled to a certain height, so that its contact with the lead is very slight and short, which makes a difference.

Very truly yours,
SAMUEL WEBBER.

LETTER FROM JAMES R. CHILTON, M. D.

New York, June 12, 1848.

DR. SAMUEL L. DANA, LOWELL, MASS.,

Dear Sir, — Your favor of the 6th inst. was duly received, and would have been answered sooner, had my time permitted.

Some few months after the introduction of Croton water into our city, my attention was called to investigate its action upon the lead pipes, which were used to carry it into dwelling-houses, &c. In several instances I detected lead in the water which had stood in lead pipes over night, in situations where free use was made of the water during the day, and in some instances this daily use had continued for several weeks. I have also found notable quantities of lead in Croton water, which I drew from a lead pipe in the third story of a house, at least a year after the pipes had been fitted in the house. The water was but seldom used from this pipe, and that which I drew from it for examination had probably remained in it for more than a week. Subsequent to this I made a series of experiments, with a view to determine the action of Croton water upon pipes made of pure lead, and of alloys of tin and lead, and also those made of lead coated with pure tin, after the plan of Mr. Ewbank. These pipes, of some thirty or forty feet in length, were filled with water brought in a cask from the Croton River. The water was displaced from the pipes by admitting a fresh supply at intervals of a day or two, for three weeks; and that which escaped was tested each time. The result proved that the water which passed through the lead pipe always contained lead, while that from the pipe made of the alloy of tin and lead, as also that from the pipe coated with tin both upon the inside and outside, did not contain a particle of lead, but for the first few days yielded a trace of tin. It is possible that the water, in passing rapidly through a lead pipe of moderate length, in constant use, may not become so impregnated with lead as to be injurious to health. But there are hundreds of instances where the pipes are conveyed to the second and third stories of houses where the water is seldom used, but from which the servant may find it convenient to fill a pitcher. The internal use of the water from such situations, I have no doubt, is highly

injuriously, and manifests itself by tremulousness and general debility of the nervous system.

With much esteem, I am your obedient servant,
JAMES R. CHILTON.

EXTRACTS FROM A LETTER WRITTEN TO DR. ANDREW NICHOLS, OF DANVERS, MASS., BY A LADY OF THE HIGHEST RESPECTABILITY, RESIDING IN NEW YORK.

This letter was not written with any expectation that it would ever meet the public eye, but the writer has kindly permitted me to "make her testimony contribute to avert from others that sorrow which presses so heavily upon herself." It is most devoutly to be wished, that such may be its effect; but whatever influence it may have, as a graphic description of many of the anomalous effects of using water lead-transmitted, it is invaluable. With respect to the disorder of the son of the lady, to which her letter refers, I have no doubt it was a case of lead arthralgy. If, in Paris, as Tanquerel states, (p. 110,) the greater part of physicians do not know how to distinguish lead colic, it may reasonably be questioned, whether lead arthralgy would be more surely recognised in this country, where even the name of this disease is not generally known.

"New York, Feb. 19, 1847.

"For several years I had been most impatient for the completion of this aqueduct," (the Croton;) "and in the autumn of '42, before I returned to town, I had the water introduced through my house. I had been spending the summer in the country, and was in much better health than usual. Before I had been at home three days I began to feel excessively heated, and then very cold, with profuse cold perspirations; to this succeeded great numbness in my head and arms, apparently some approach to paralysis, attended with acute neuralgia and great torpor of the digestive organs; and indeed so great a multitude of distressing sensations of every description, that it is useless to attempt an enumeration of them. All these I could have summoned fortitude to endure, but the irresistible depression of spirits which accompanied them was absolutely appalling. Every day my sufferings increased, when about three weeks after I happened to see my large white marble plunging bath filled with water. I was immediately struck with the color of the water, it was dark brown. I knew that the large iron conductors had been laying corroding in the ground for years, and as I had been invariably

injured by all the different preparations of iron which had been administered to me by my physicians, I came at once to the joyful conclusion that it was only an old enemy in disguise. I discontinued the use of Croton water, and in a few days was as well as usual. I tried it repeatedly; precisely the same sensations always followed, and always gradually disappeared on my resuming the hard water.

"How much the iron rust may have operated upon me I suppose it is impossible to determine. But since then I have been affected in the same way both in the town and in the country, by rain water which had never come in contact with iron, but which passed through leaden pipes. For the last two years I have avoided the Croton water more than at first, because, beside its other long list of evils, it now produces a violent cough.

"When we first had this water I allowed my children to take it without reserve; at the expiration of about two months my eldest son, then nearly four years of age, began to fail, all remedies proved unsuccessful, he appeared fast sinking into the grave; one day I stood over his bed feeding him with Croton water, for his thirst was insatiable, and I observed that at one moment his face would be suffused with the most vivid crimson, and at the next reduced to ashy paleness; it was the same flush that the Croton water produced on me. I substituted the pump water, and a few hours after, when Dr. — paid his second visit for the day, he was amazed at the extraordinary improvement which had occurred during his absence. I gave up almost entirely the use of the medical prescriptions, and adhered to the pump water, and the child rapidly recovered." The lady, by the request of her friends, in the spring of 1846, allowed the children to drink Croton water, "I cannot," she continues in her letter, "recollect how long they used it; but after some time my eldest son, the child that I have just mentioned, was seized with inflammatory rheumatism, suffered intensely, and was wasted to the most perfect skeleton."

Note. — The day before this last attack, the family had removed into the country, where pure spring water was obtained. It was not till after this, viz. Oct. 18, 1846, that I received from my friend Dr. Nichols, a sample of the water for analysis, with which he had been furnished by the parties interested. — S. L. D.

LETTER FROM A. A. HAYES, M. D., STATE ASSAYER OF MASSACHUSETTS.

Lowell, June 13, 1848.

MY DEAR SIR,

In reply to your request that I would furnish you with the particulars of instances of my testing Jamaica Pond water, which, from standing in

lead pipes, had become impregnated with lead salts, I have to regret that no notes of such cases were made at the times. My dependence is therefore wholly on the general conclusions formed from testing more than one hundred samples. I have also studied the action of this water on lead pipes, in the laboratory, and more recently have made quite a series of observations with careful attention.

I remember in cases of testing, that Jamaica Pond water, drawn through lead pipes, contained salts of lead in two states, *dissolved* and *suspended*, and in some cases wholly *suspended*; the clear water affording no traces of lead. There are other cases depending in their results from the same pipe, on the season of the year, and state of the water in the pond. In general, the water acted on the pipes so far as to produce corrosion over extensive surfaces, and the lead compounds formed were either dissolved, so as to produce a clear lead water, or where diffused through the mass of water, slight traces being dissolved, or entire freedom from contamination existing in the water. I have examined lead pipe which had conducted the water of Jamaica pond, and found its surface in contact with the water, eroded, with adhering compounds of lead partially covering it.

Samples of the water have been tested, in which no traces of lead could be discovered, but after some months the recently drawn water from the same pipe contained lead compounds dissolved; the *state* of the water, not the lapse of the time, favoring solution.

Comparisons of this water with the Cochituate have been made at various times since the introduction of the latter into the city of Boston had been determined on, with special reference to its relations to lead, and through the great number of trials a close correspondence was observed. I know of no difference of composition which would lead us to class this with any other than ordinary lake or pond water.

Sincerely yours,

DR. DANA.

A. A. HAYES.

EXTRACTS FROM A REPORT TO THE CITY COUNCIL OF LOWELL.

The fact so well known, that leaden pipes are corroded and destroyed by water, would long ago have told the effects of using such water, were it not that the disorders produced by it are of such slow and insidious character, that they have been attributed to other sources, till chemical analysis has pointed out a cause of disease more to be relied on than doubtful speculation.

That lead, in continued small doses, is a cause of disease and

death, is the accumulated testimony of two thousand years. Yet the metal is used where its use is most dangerous. Men are roused to a sense of its danger, only when the frequency of the disease, attended often by a fatal termination, has spoken in tones which chill the hearts of the bereaved, and alarm the living sufferers by well grounded fears, that the seeds of deathly disease may be germinating in their constitutions.

It may be stated, that the usual form under which we are accustomed to see the effects of lead, viz: — "Painter's colic," is only one form of its effects. Paralysis too, constipation, dry belly ache, purging and vomiting are not unfrequently witnessed, consequent to the use of lead. These cases cannot, and generally have not been mistaken. But there is reason to believe that a vast many cases of rheumatic and spasmodic and nervous disease, a general breaking up, as it were, of the foundations of the great deep of life, have occurred, which can be attributed only to the effects of small, daily doses of lead.

Medical books contain records enough of the effects of lead, to warrant the conclusion, that it is a frequent cause of disease and death. That its use is not always, in all persons, followed by evil, is to be found in the fact, that every one has his own constitution, as he has his own face. The countenance may not be so ill-favored as to forbid the hope, that possibly it may be by some one thought handsome; so too, in each man's constitution, it is only a presumption, that lead may not affect it. If we consider the chemical action of lead on the tissues of the body, it will be seen that the presumption is, that lead will and does affect all constitutions. As it is not in the capacity of a physician, but of a chemist, that your committee have requested my opinion, I beg leave to confine my remarks on the effects of lead, to its chemical action.

What is the constitution, upon whose firmness we repose our trust, that lead is harmless? The constitution is only a greater or less degree, of vital force. Life is the vital force, manifested under the control of a higher influence; the nervous influence, it may be, too spiritual for the cognizance of our senses. The vital force is cognizable by its effects, as are the effects of electricity, magnetism, light, heat. The vital force is as much a power or agent, as is either of these. All agents act chemically on the tissues of the animal body living, as they would upon dead matter. Their agency is limited and controlled by

the vital force. If that is strong, so much less is their action. One man differs from another, as a horse, for instance, differs from a man. A horse may take daily, for weeks, several grains of arsenic, without other effect than a softer and more silky skin. In this sense of the constitution, a difference in degree only, of that agent called the vital force, it is found by experience, that the young, the delicate, soonest succumb, under the effects of lead drank in their daily drink, and like the dews of heaven, descending on all, the gentlest and fairest, first feel the chill which soon closes in death.

Understood then in this sense, the vital force is continually opposing the chemical action of agents on the body. Lead belongs to that class of agents called poisons, the inorganic or mineral poisons. This class is distinguished from others, by this circumstance, that owing to the great tendency to unite chemically with the tissues of the body, they rarely pass into the circulation. These poisons unite with, and form a part of the living structure. The effect of this combination is, the total destruction in the part where it takes place, of the power of effecting and producing those chemical changes, in which mere life, unattended by nervous influence, consists; or in other words, poisons, by combining with the tissues, destroy their organic life.

A constant struggle is going on between the vital force and the chemical action of the poison. If this is in small quantity, or of feeble power, or the vital force strong, then combination takes place only in a small degree. In some cases the poison remains combined, without producing the death of the part. In others, this destruction of the substance occurs, and is followed as a burn on the skin would be, by inflammation, and casting off the dead, by the living parts. In general, a great shrivelling of the parts to which the poison is applied, takes place. In other cases, the combination not totally destroying, but only impeding the healthy functions, goes on quietly for years, each year adding its force to the preceding, yet leaving no visible trace in the parts, of its action, till finally the whole system becomes so combined with the poison, that death ensues. In the case of lead, the poison once combined with the tissue, is redissolved by an excess of the poison, and the parts are thus affected, with a general softening and pulpieness. This is, I believe, not an unfrequent trace of disease, which is found on dissection of those who have been supposed to have died from the effects

of lead. From the chemical action of lead, it is evident, that we are not to look for marks of violent disease, after death, but rather for thickenings, hardenings, contractions, or great softness.

All mineral poisons act only when in solution, or are capable of being dissolved in the stomach. Arsenic, in its insoluble forms, is as harmless as sulphur. All substances which have the power of combining chemically with the animal tissues are poisons. But this class includes, especially, the metals, when formed into oxides or salts. Mercury, or corrosive sublimate, arsenic, lead, tin, zinc, copper. These all belong to the same class — they all operate alike — they differ only in the degree of force with which they operate. With this the constitution has nothing to do. Their difference in this respect is manifested as well on the dead as the living body. The same chemical combination takes place. In the living body, the poison, having overcome the vital force, that part is as much under the control of chemical laws, though surrounded by living parts, as if it were cut out of the body. Chemical combination takes place in definite proportion, and hence when it is considered that all the animal tissues have, what chemistry calls, very high combining numbers, and the metals very low, it is easily seen how a very small proportion of the last may destroy a very large proportion of the first. About one grain of lead will completely neutralize and destroy vitality in one ounce of flesh or blood. How small a portion then, will impede the healthy functions of the body!

The mineral poisons then, all acting by uniform laws, the difference in their effects depends not upon constitution, but upon their own inherent nature. This difference amounts to this, that some operate at once like a hot iron, others only sear, without destroying the complete vitality of the part. They combine only slowly. This is the case, I suppose, with lead. It is one of the poisons which, from the smallness of its dose, and large dilution, I suppose enters the circulation. It gradually impedes the action of whatever part it combines with, bringing on disease, with a long train of anomalous symptoms, till finally, before the cause has been suspected, and while the sufferer is still under the daily influence of that cause, the deposited lead begins to be re-dissolved, a general softening of the vital organs takes place, and Death, the greater master chemist, closes the Laboratory of Life.

Who may presume then, considering the chemical action of lead on the human system, that his constitution is safe? Such presumption is indiscreet.

ON THE PROPOSED SUESTITUTES FOR LEAD.

Common sense would lead to an abandonment of lead in our wells, aqueducts and cisterns. The question is, what shall be substituted — cheap, efficacious and wholesome. Here, too, we must look to chemistry for the answer, if any metal except iron is to be substituted for lead. Among the metals, copper, tin, zinc, or their alloys with each other, or with lead and iron, have been proposed. Let us first attend to the pure, that is, commercially pure metals themselves. Copper, tin, zinc, would each be, if used alone, acted on by the same salts and acids, which have been shown to act on lead. The compounds which they would form, are, in each metal, much more soluble than the similar compounds with lead. The free sulphuric acid which may exist in water, not only in the absence of nitrates and muriates, would at once dissolve these metals, but the acids which would be eliminated from its action on such salts, will act with great energy on these substances. The same action which corrodes the copper sheathing of a vessel, will occur in well water, on tin, zinc, copper.

The soluble salts of all these metals are poisons. Copper and tin are much more active than lead. Copper is easily reduced from a poisonous to a harmless state by sugar. Tin more readily combines than lead with the elements of food. Hence, though copper and tin are more active poisons than lead, they are less liable so to act. Zinc is least active. Indeed, it has been questioned, whether it acts at all as poison. From the laws of the action, which have been stated of these substances on the animal tissues, it may not be doubted that the commissioners, repeatedly authorized by the French government, to investigate the effects of zinc, acted wisely when they uniformly reported against the use of zinc, in vessels used for private or public convenience.

From the earliest days, alloys of these metals have been used. Experience taught, that these alloys were less acted on than the separate metals. If water was as pure as air, then the same results might be anticipated from their use, as water pipes.

But experience has also taught, that a portion of these alloys are, when in contact with certain substances, more rapidly acted on, than would be the separate metals.

These facts have remained unexplained till the days of Davy, and his explanation of the cause led him to protect copper by iron and zinc; and this again has led to the protection of lead by tin, and of iron by zinc, under the name of galvanized iron. Now, as all these alloys and protectors have been proposed to be used, it may not be amiss to glance at the principle on which their action depends.

Two metals, in contact, are found to be in different states of electricity. One is positive; the other, negative. This depends not on any inherent power of the metal itself, for a metal positive with one may be negative to another. The fact to be regarded is, that the metal upon which chemical action readiest takes place, is always positive. Hence the two sides of a single plate of metal will exhibit different electricities, if one be plain and smooth, the other rough. In general, that metal which rusts easiest, is positive to the other. Now, taking these facts as the guide, metals have been arranged in the following order, each being positive to all below it, and negative to all above it.

Zinc,
Iron,
Lead,
Tin,
Copper.

Each metal protects all below it. But this, the common order in air, is modified by the nature of the fluid in which these alloys, or galvanized metals, are placed; for,

The order in alkaline solutions, and in solutions of common acids and salts, is as follows:

In alkaline solutions (as lime water):

Zinc,
Tin,
Lead,
Copper,
Iron.

In acid solutions (as Lowell well water):

Zinc,
Tin,
Iron,
Lead,
Copper.

The principle on which protection depends, is of the highest practical importance. That principle is, that the protecting metal is itself always dissolved. The above three series show,

that different effects will take place in different circumstances. But, regarding here the last series, the facts are in accordance with the long and patient series of observations made in France, that in alloys of lead and tin, as pewter and Britannia ware, the tin is first dissolved. So, too, that profound chemist, Dr. Thomson, found the tin in tea lead, of which it is about four per cent., was always first dissolved; and actual experience has shown, that the tin has been eroded through, and the lead acted on by Croton water, where the tin coated lead pipe has been used for some months. So also the experiments reported by Mr. Solly, to the Royal institution in 1847, show that the presence of zinc, as a protector of lead pipe, greatly hastens corrosion, and the water thus is rendered still more impure. I have by me specimens of the material used in the original experiments of Davy, to protect copper sheathing by cast iron. Every particle of the iron is removed. It has been dissolved by the sea water, and only a light spongy mass remains, like black lead. It is the earthy and organic part of the cast iron.

Bearing these facts in mind, it is to be noticed, that leaden pipes are themselves sometimes adulterated. This accident arises from the natural impurity of the lead, or from the fact, that in melting large masses of pure lead, the rust or oxide often is combined with the pure metal. This would be the first attacked in those places. Impurities may arise, if old lead, often used with its solder, is employed to be drawn into pipes. Hence it is seen why lead is eaten in pits and channels.

The facts stated would lead us to anticipate what would be the result of using any of the substitutes for lead, which have been proposed. Of these, copper, tinned with pure tin, is the least objectionable; tin and lead, considering the variations to which they are exposed, the most objectionable. There remains zinc and iron, or galvanized iron, which would seem to recommend itself by its cheapness, as it can be afforded, made from the sheet, including the bends, &c., of cast zinc, about as low as lead.

However confident one may feel, of the results of the action of salts and the metals, I was unwilling to discourage the resort to galvanized iron without experiment.

1. I find, that the zinc is rapidly dissolved in a very dilute solution of common salt in water, and may be found in the solution, or water, as the muriate of zinc. This would be the action

of the common salt in rain water, and it is the source of the corrosion of zinc roofs.

2. Galvanized iron, introduced into a solution of copperas in water, very dilute, acts thus: I soon found iron rust rapidly falling on the galvanized pipe. In a short time, *all* the iron was precipitated from the water, and fell in a coat of rust, while its place in the water was supplied by zinc. In other words, copperas or green vitriol was exchanged for white vitriol.

3. Galvanized iron, in a mingled solution of salt and of copperas, such as is found in several wells in Lowell, is rapidly destroyed; the water becomes charged with salts of zinc.

I should therefore recommend,

1. Wood, wherever it can be used;
2. Cast iron, or wrought iron tubes;
3. Copper, protected by pure tin.

The use of all other metals, and alloys of these, in the present state of our knowledge and experience on these subjects, ought forthwith to be abandoned.

The above recommendations made a part of the report to the City Council of Lowell, in 1842. Time has strengthened my confidence in the use of *pure* tin coated copper pipe. It must be entirely *alloyed* with the copper on each and every part of the surface. Experiments are now in progress, with a great probability of success, to connect the joints by screw couplings of pure tin, for even the solder, used to unite these, may not be wholly harmless. But every precaution should be taken, that the tin used should be perfectly free from lead. No lead should be added to make the tin *flow*, and the South American or Spanish tin must be most scrupulously avoided. It is sometimes alloyed with twenty per cent. of lead. Cases have been brought to my notice, where, with all that care which marks the integrity of the honest artisan, an impure lead alloyed tin had been used for covering the copper, and, as might have been foreseen, the water became impregnated with lead by immersing such a compound in it. Nothing but *pure tin*, it may be repeated, should be thus used. With this precaution, "pipes thus made have been exposed to most kinds of natural waters, under varying circumstances, and in no instance has the water been contaminated, or the surface of the pipe corroded. The surfaces of these pipes present a thin covering of pure tin, or an alloy like bronze; one of the most indestructible of metallic compounds.

When exposed to wells, under soil, and in moist air, these pipes remain wholly unimpaired. Except the noble metals, I know of no metallic substance preferable to this as a material for service pipes. The daily use of water from such pipes for ten years, in addition to observations made in the laboratory, lead me to prefer pipes made by combining pure tin with the surface of copper, for all situations where small pipes are required. They are, even when quite thin, strong enough to resist ordinary pressure; are easily bent and united together." (A. A. Hayes, *Report of Consult. Phys. of Boston*, 1848.)

The cost of copper pipes, thus tinned and connected by tin couplings, will not be more than one third higher than that of lead pipe of the same calibre, and under the same pressure.

END OF APPENDIX.

SYNOPTICAL TABLE.



SYNOPTICAL TABLE.

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SYNONYMES.

The physicians who have observed lead colic, finding no description of the disease, gave it the name of the country where it was seen. Hence the names of colic of *Poitou*, of *Devonshire*, of *Normandy*, of *Madrid*. It is called also *painters'*, *plumbers'*, *potters'* colic, after the trades in the members of which it most often appears. *Lead colic* is the most appropriate name 29

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HISTORY.

Hippocrates is presumed to have known lead colic. Nicander has described lead colic and paralysis. Celsus was aware of the danger of lead medicine. Dioscorides enumerates the symptoms of lead colic and paralysis from internal use of lead, or by breathing lead emanations. Galen describes colic identical with that of lead. Aretæus and Paul of Ægina describe lead diseases. Ætius calls lead a poison 31

Rhazes, Haly-Abbas well knew the bad effects of lead, and Avicenna has given a true description of lead colic. Remarks on the amount of the knowledge of the Greek, Roman, and Arabian writers on lead colic 32

In the *middle ages* many writers spoke of lead colic, but made no addition to the previous knowledge. Paracelsus, Drouet, and Craton consider lead colic and paralysis as accidents of lead poisoning, but do not give an exact account of the causes 33

In the *seventeenth century* many tracts on lead colic appeared. Citois published his famous *Diatriba* on lead colic 1616. He did not know the cause of the disease he described. Stockhausen first demonstrated that colic is caused by lead emanations or particles. He is the father of the true history of lead colic 33

Wepfer, Sydenham, Van Helmont, Willis, &c. mention lead colic . . . 34

The *eighteenth century* abounds in new works, adding to our knowledge of lead colic. Henkel proved experimentally that lead alone caused lead colic. Dehaen published many tracts on lead colic, worthy of praise.

Huxham described lead colic; the English physicians and chemists proved lead in cider to be its cause. Astruc attempted to show that

lead colic is rachialgy. The treatise of Dubois enjoys an unfounded reputation. Gardane translated into French the masterly work of Stockhausen. Bonté published valuable papers on colic in the Medical Journals. Stoll affirmed that lead causes colic. Luzuriaga, in 1796, published a treatise on Madrid colic 35

In the *present age*, Larrey and other French physicians describe Madrid colic, which they think is not due to lead. Merat published a dissertation in 1804, and in 1812 a treatise on lead colic. Andral reports several cases of this malady in his "*Clinique*," and Canuet and Grisolle present valuable tracts on lead colic to the Medical Faculty of Paris . . . 36

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